Fecha: jueves 14 y viernes 15 de noviembre de 2024

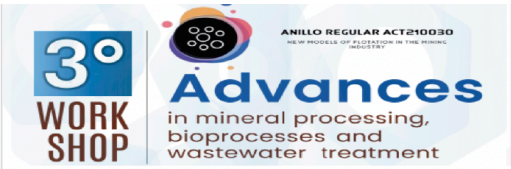
Lugar: auditorio Hermann Alder Weller, CI²MA-UdeC

Este evento cuenta con el apoyo de la Agencia Nacional de Investigación y Desarrollo, **ANID**, a través de los proyectos **CRHIAM** (ANID/Fondap/15130015), Anillo '*New models of flotation in the mining industry: simulation, experimental validation, and prediction tools for treatment of complex ores*' (ANID/PIA/ACT210030), **Centro de Modelamiento Matemático** (CMM, proyectos BASAL ACE210010 y FB210005) y Fondecyt 1210610.

Organizadores: Luis-Miguel Villada (UBB) Fernando Betancourt (UdeC), Raimund Bürger (UdeC)

Contenido

Programación

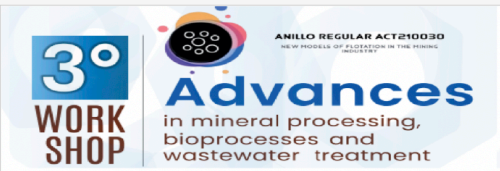


November 14-15 2024
Universidad de Concepción
Concepción, Chile

Programa general

Jueves 14 de noviembre

Horario				
10:00	11:00	Coffee - Registro		
Sesión 1		**Expositor**	**Título**	**Universidad**
11:00	11:10	Fernando Betancourt	Discurso de apertura	UdeC
11:10	11:35	Osvaldo Bascur	Maximizing copper production by proper water management using a digital twin	OSBDigital,LLC
11:35	12:00	Gonzalo Quezada	Simulación de Interacciones Superficie-Polímeros en Minería: Un Enfoque Molecular para el Diseño de polímeros	U Bio Bio
12:00	12:25	Luver Echeverry	Simulación dinámica molecular de la extracción de lantano utilizando un solvente eutéctico profundo	UdeC
12:25	12:50	Antonio García	Model-based predictive control for pneumatic separation and classification of materials in lithium-ion battery recycling	UCN
12:50	15:00	Almuerzo		
Sesión 2		**Expositor**	**Título**	**Universidad**
15:00	15:25	Lina Uribe	Evaluation of the use of mixtures of recycled vegetable oil esters and biosolids as collectors for the flotation of copper sulfides	UTAL
15:25	15:50	Lina Chica	Control de la operación de un hidrociclón desde una aproximación energética	UMedellín
15:50	16:15	Camila Rodríguez	Evaluation of the impact of polystyrene nanoparticles on the flotation of pyrite and molybdenite	UTAL
16:15	16:40	Daniel Zuluaga	Study of the Interaction of collectors prepared by waste oil and biosolid and Iron Sulfide Minerals in flotation processes	UTAL
16:40	17:05	Felipe Arcos	Impact of a Residual Anionic Polyacrylamide and its Mechanical Degradation Level on Chalcopyrite Flotation	UdeC
17:05	17:30	Coffe cierre jornada		



November 14-15 2024
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Programa general

Viernes 15 de noviembre

Horario		Sesión 3	Expositor	Título	Universidad
09:00	09:25		Christian Ihle	Predicting the unpredictable: Assessing the consequences of slurry pipeline failures using CFD	UCH
09:25	09:50		Luis Vinnett	Impacto de la elección de los tiempos de muestreo en la Caracterización cinética y en el escalamiento de la flotación	UTFSM
09:50	10:15		Gina Jiménez	Influencia de la poliacrilamida aniónica en la flotación de molibdenita en aguas de diferente fuerza iónica.	UdeC
10:15	10:40		Pablo Cabrera	Diseño y Simulación de un Reactor de Alta Velocidad para la Aglomeración de Minerales Finos en Presencia de Óxido de Polietileno (PEO).	UdeC
10:40	11:10		Coffee Break		
		Sesión 4	Expositor	Título	Universidad
11:10	11:35		Andrés Ramírez	Acondicionamiento de burbujas como una alternativa para mejorar la flotación de minerales sulfurados de cobre y molibdeno.	UdeC
11:35	12:00		Raimund Burger	The effect of bias flow and numerical simulation of the transport of liquid components in a model of a flotation column	UdeC
12:00	12:25		Juan Barajas	Invariant-region-preserving central WENO schemes for one-dimensional multispecies kinematic flow models	U Bío-Bío
12:25	12:50		Luis Miguel Villada	Sedimentation of Polydisperse suspensions in inclined channels	U Bio-Bio
12:50	13:15		Fernando Betancourt	Coupled finite volume methods for settling in inclined vessels with natural convection	UdeC

Expositores

Dr. Antonio García (Universidad Católica del Norte, Antofagasta)

Título: Model-based predictive control for pneumatic separation and classification of materials in lithium-ion battery recycling

Resumen:
Due to the considerable number of lithium-ion batteries (LIBs) required for telecommunication systems, electric transport, and renewable energy storage, among other applications, the recycling of spent LIBs is considered an increasingly critical operation. Thus, the improvement of this operation can reduce manufacturing costs, the consumption of raw materials, and the environmental footprint produced by their disposal. The present work is focused on implementing advanced control strategies for the separation and classification stages in spent LIBs recycling. The control strategies used correspond to model-based predictive control (MPC). The methodology consisted of implementing a phenomenological model that represents the operation of a device that separates and classifies materials based on their physical properties and uses an air jet as a suspension media. The numerical method solving the phenomenological model was programmed in Fortran language and compiled in the Intel® Fortran Compiler because of its shorter computing time, and the algorithm implementing the nonlinear MPC controller was executed through Matlab software. In addition, the study presents five control scenarios simulated considering performance approaches and one scenario regarding economic approach. The two manipulated variables example obtained the highest relative error for the output variable concerning the set point, with 1.7125%. So, implementing MPC controllers for the material separation stage in LIBs recycling would allow the improvement of these processes in both performance and economic aspects.

Dr. Christian Ihle (Universidad de Chile)

Título: Predicting the unpredictable: Assessing the consequences of slurry pipeline failures using CFD

Resumen:
The frequent occurrence of pipeline failures underscores the importance of risk analysis for cross-country ore hydraulic transport operations. Computational fluid dynamics (CFD) offers a valuable tool for predicting the progression and final condition of spills resulting from pipeline leaks. This talk presents a two-dimensional numerical model to simulate a slurry pipeline rupture and subsequent spill. The model is employed to analyze two topographic scenarios-a mild slope and a steep slope—to assess the potential requirements for emergency response. Results, obtained using different slurry rheologies, are compared with those obtained using a simpler flow resistance model for water. The findings highlight the influence of both slurry rheology and terrain conditions on the spreading behavior, emphasizing the need for their consideration in risk assessment and mitigation strategies.

Dr. Gonzalo Quezada (Universidad del Bío-Bío.)

Titulo: Simulación de Interacciones Superficie-Polímeros en Minería: Un Enfoque Molecular para el Diseño de polímeros

Resumen:
El uso de polímeros en la industria minera, especialmente en procesos como el espesamiento de minerales, ha sido clave para mejorar la eficiencia en la separación de minerales. Los polímeros convencionales, como los derivados de acrilamida, han demostrado ser eficaces en este ámbito. Sin embargo, su impacto ambiental ha impulsado la búsqueda de alternativas más sostenibles, como los biopolímeros derivados de polisacáridos.
En este trabajo, se presenta un enfoque basado en simulación mediante dinámica molecular para estudiar la interacción entre superficies minerales y polímeros, evaluando tanto los polímeros convencionales como nuevas alternativas biodegradables. En particular, se analizan biopolímeros derivados de polisacáridos con el fin de determinar su viabilidad como reemplazo de los polímeros sintéticos utilizados actualmente en la industria minera.
A través de simulaciones atomísticas detalladas, se investiga cómo estos biopolímeros interactúan con las superficies minerales, estudiando parámetros clave como la adsorción, la estabilidad y la formación de redes que favorezcan el espesamiento de suspensiones minerales. Los resultados preliminares sugieren que existe potenciales capacidades de los biopolímeros a generar interacciones estables con los minerales presentes en el relave y además que sean resistentes a la salinidad.

Dr. Osvaldo Bascur (OSBDigital,LLC)

Título: Maximizing copper production by proper water management using a digital twin

Resumen:
Low grade ores mineral processing plants require large amounts of energy and water to operate in a sustainable and profitable state. These ores present large variations in their mineralogy, metal content and hardness. These low-grade ore plants are processing mostly rock in the first part of the process, followed by the traditional mineral processing and water recovery systems. Currently, mineral processing plants operate in silos and lack the necessary integration of data from mining, grinding, classification, flotation, thickening and tailings processing. The lack of process information with the right degree of detailed are missing for understanding the integrated process. Today, tight coordination between the mining product, grinding, classification, flotation and water recovery processing is a must.
A novel strategy using a Digital Twin was designed to increase the necessary water recovery from the thickeners and tailing ponds to maximize the copper production rate in a low-grade ore industrial plant. The right grinding particle size distributions shape products are monitored to improve both for flotation metal production rate and flocculation of the tails produced in the rougher flotation. The plant data model consists of a Rock Processing, a Water Processing which integrates the plant to find the best operating conditions that optimize the copper production rate base on the plant schedule.

The implementation of the Digital Twin results are: a 40% increase in water recovery for a maximization of copper production rate of 32%. These savings are very significant based on zero-capital investment requirements with using their actual process historian data infrastructure. The OSB Digital Twin is based on the implementation of an integrated mineral processing plant model built using the PI System and OSB Grinding, Flotation and Thickening dynamic simulators. The critical process operational modes are calculated based on the plant business plan and current data to transform the timeseries raw data into information to build the necessary machine learning models. These models are used to understand the integrated behavior of the plant and to avoid violating costly process constraints in the grinding, classification, flotation and thickening processes.

Dr. Luis Villada (Universidad del Bío-Bío.)

Título: Sedimentation of Polydisperse suspencions in inclined channels

Resumen

In this talk, a two-dimensional model for settling polydisperse suspensions in inclined channels is presented. This model is the coupling of a system of conservation laws with a Stokes-type equation. A Finite Volume Numerical Method (FVM) is proposed to approximate the solution of these equations. To do this, we consider a Lax-Friedrichs-type numerical flux to approximate the hyperbolic part and employ a finite volume approach to discretize the Stokes problem. We detail the coupling algorithm and simulate some scenarios of interest. The presentation is based on ongoing research done jointly with R. Burger (CI2MA-UDEC), J-D Barajas (Universidad del Bío-Bío) and Pep Mulet (Universitat de València, Spain)

Dra. Lina Uribe (Universidad de Talca.)

Título: Evaluation of the use of mixtures of recycled vegetable oil esters and biosolids as collectors for the flotation of copper sulfides

Resumen

In the mining industry there is a need to advance in sustainable development. It is necessary to propose new environmentally friendly reagents that achieve better performance and contribute to the circular economy at the same time. In this research, the technical feasibility of the use of mixtures of recycled vegetable oils esters (ERVOs) and biosolids (BSs) as collectors of copper sulphide minerals in the flotation process is studied.

The study considered flotation tests at laboratory scale with synthetic ores (chalcopyrite, pyrite and quartz) in order to evaluate the flotation kinetics of ERVOs and BS by separated, analyse the metallurgical indexes to use different ERVOs/BS mixtures and compare these results with the obtained with the conventional collector potassium amyl xanthate (PAX).

Results obtained in this study showed that, the kinetic flotation of RVOs and BS was faster than the obtained with PAX collector. Also, although a lower recovery of copper with the mixtures of ERVOs/BS than PAX collector was obtained, the studied ERVOs/BS mixtures reached a higher enrichment ratio and selectivity index with respect to pyrite. However, lower recovery of copper with the mixtures were reached comparing the PAX reagent. According to these results, it is possible to suggest that the use of ERVOs/BS has the potential to be used in the cleaner stages. This could represent a combined opportunity to reduce costs in the flotation process and minimize the environmental impact generated in the mining and sanitary industries.
Join work with Daniel Zuluaga (Universidad de Talca), Carlos Moraga (Universidad de Talca), María del Pilar Caramantín (Universidad de Talca), Lorenzo Reyes-Bozo (Universidad Autonoma de Chile)

Estudiante PhD Camila Rodríguez (Universidad de Talca)

Título: Evaluation of the impact of polystyrene nanoparticles on the flotation of pyrite and molybdenite

Resumen:
In recent years, copper deposits in Chile have undergone significant changes in mineral grades and mineralogical composition. The presence of clay minerals in copper sulfides, particularly montmorillonite, negatively impacts the flotation process. However, polystyrene nanoparticles have demonstrated great potential for improving copper recovery in clay-rich environments. On the other hand, copper sulfides like chalcopyrite are often associated with gangue minerals such as pyrite, which decreases the effectiveness of valuable mineral recovery. Additionally, molybdenite, a high-value by-product, is frequently found alongside chalcopyrite, making its efficient separation crucial for maximizing recovery. Despite this, the effects of this reagent on by-products like molybdenite and on gangue minerals like pyrite remain largely unexplored.
This study aims to evaluate the use of polystyrene nanoparticles for recovering pyrite and molybdenite, seeking to enhance the recovery of valuable minerals in complex conditions. Zeta potential measurements, micro flotation and contact angle tests were conducted at different nanoparticle concentrations. Preliminary results show that polystyrene nanoparticles significantly reduce the hydrophobicity of pyrite compared to potassium amyl xanthate (PAX), at a concentration of 5.6 mg/g, pyrite recovery decreased from 94% to 8% in the presence of nanoparticles, improving flotation selectivity. On the other hand, molybdenite recovery was not significantly affected, as it only decreased from 95% to 80%. Zeta potential tests indicate that at a concentration of 2.8 mg/g, nanoparticles can achieve a surface charge change in both pyrite and molybdenite. These results suggest that nanoparticles could optimize the separation of chalcopyrite by preventing the pyrite recovery without critically compromising the recovery of valuable minerals such as molybdenite
Join work with C. Rodríguez (Universidad de Talca), R. Murga (Universidad de Talca), J. Amalraj (Universidad de Talca), L. Gutierrez (Universidad de Concepción) and L. Uribe (Universidad de Talca)

Dr. Luis Vinnett (Univerisdad Tecnica Federico Santa Maria)

Título: Impacto de la elección de los tiempos de muestreo en la Caracterización cinética y en el escalamiento de la flotación

Resumen
La flotación es la principal técnica de concentración de minerales sulfurados a nivel mundial. La eficiencia del proceso se ve influenciada por múltiples factores altamente aleatorios, incluyendo variables mineralógicas, físicas, químicas y operacionales, las cuales impactan tanto en la recuperación como en la calidad del concentrado. La caracterización cinética es crítica a la hora de dimensionar circuitos de flotación; sin embargo, las estrategias de modelación utilizadas en la actualidad han tendido a la arbitrariedad y a la sobre-simplificación, dada las múltiples posibles respuestas causadas por la heterogeneidad de la alimentación. Dado que el escalamiento por tiempo ha sido ampliamente utilizado con fines de dimensionamiento, este trabajo considera la identificación de respuestas tiemporecuperación, incorporando un número significativo de puntos en comparación con lo típicamente empleado en estudios cinéticos (< 8 datos tiempo-recuperación). Estas respuestas son sub-muestreadas de manera de obtener un número de datos tiempo-recuperación comparable a lo utilizado en pruebas de laboratorio industriales, tanto para control de procesos como para el dimensionamiento de circuitos. La información sub-muestreada es modelada usando representaciones cinéticas clásicas, evaluando la incertidumbre en la estimación de parámetros. Se analiza también la incertidumbre en la predicción de recuperación, proyectando los resultados de laboratorio a escala industrial, usando los factores de escala mayormente aceptados en flotación. El estudio contribuye en el análisis de respuestas pobremente muestreadas, evaluando su impacto en el escalamiento de la flotación de minerales.
Join work whit Alex Esteban Copa

Estudiante PhD Felipe Arcos (Universidad de Talca)

Título: Impact of a Residual Anionic Polyacrylamide and its Mechanical Degradation Level on Chalcopyrite Flotation

Resumen:
The recirculation of water in mineral processing plants is an effective solution to the current water scarcity problem. However, this causes some operational challenges that can affect the efficiency of the operation, such as the presence of residual reagents and fine particles. This research shows the depressing effect of a residual flocculant, such as anionic polyacrylamide (PAM), on chalcopyrite flotation under different conditions of pH, concentration and mechanical degradation of the PAM. The experimental methodology considered microflotation tests, reagent adsorption and induction time measurements. From the results, it can be concluded that the presence of PAM in chalcopyrite flotation has a negative impact on its recovery, for any level of mechanical degradation and pH evaluated. Furthermore, the decrease in chalcopyrite recovery is associated with a lower hydrophobicity of the particles, which is related to a greater interaction between PAM molecules and mineral particles. These

effects have not been previously studied and could be very useful for correct water management in the mineral processing industry.
Join work with Lina Uribe (Universidad de Talca) and Leopoldo Gutiérrez (Universidad de Concepción)

Estudiante PhD Ginna Jiménez (Universidad de Concepción)

Título: Influencia de la poliacrilamida aniónica en la flotación de molibdenita en aguas de diferente fuerza iónica.

Resumen
La industria minera presenta importantes desafíos para su desarrollo, siendo la escasez de agua uno de los más importantes. Debido a este problema, se ha visto obligada a adaptarse a nuevas alternativas, como el uso de agua de mar y agua reciclada o recirculada, lo que tiene consecuencias en la flotación de minerales sulfurados. La poliacrilamida es un floculante que comúnmente se encuentra en el agua recirculada y afecta a la recuperación de minerales sulfurados porque influye en las propiedades fisicoquímicas del proceso de flotación.
En este trabajo de investigación se estudia la influencia de la poliacrilamida recirculada en la flotación de minerales sulfurados, para este caso la molibdenita, con soluciones de diferente fuerza iónica utilizando sales como $MgCl_2$, $MgSO_4$, $CaCl_2$ y $CaSO_4$. En este proceso se analizó la recuperación del mineral por microflotación variando el pH, nivel de cizallamiento y concentración de la poliacrilamida de baja anionicidad (LPAM) y su adsorción sobre las partículas del mineral. Los resultados obtenidos en esta investigación indican que la presencia de poliacrilamida tiene un impacto significativo en la flotación de molibdenita.

Trabajo en Colaboración con Leopoldo Gutiérrez (Universidad de Concepción)

Estudiante PhD Daniel Zuluaga (Universidad de Talca)

Título: Study of the Interaction of collectors prepared by waste oil and biosolid and Iron Sulfide Minerals in flotation processes

Resumen:
The mining industry relies extensively on froth flotation to concentrate copper sulfides. Recent studies highlight the use of vegetable oils (RVO) and biosolids (BS) as promising substitutes for xanthates in froth flotation. These alternative collectors not only mitigate ecological impacts associated with traditional reagents but also promote circular economy principles by repurposing organic waste streams. This study aimed to study the type of interactions that occur on the surface of chalcopyrite (Cpy) and pyrite (Py) minerals with the RVO and BS, which allow achieving a high degree of selectivity of chalcopyrite in the flotation process. The experimental methodology consisted on to characterize RVO and BS through of Fourier Transform Infrared Spectroscopy (FTIR) and High-Performance Liquid Chromatography (HPLC), to employ microflotation test to determine the concentration of reagents which reach

to high chalcopyrite recovery. Finally, to evaluate the surface phenomena between the different minerals and reagents the X-ray Photoelectron Spectroscopy (XPS) was used.

Microflotation test evidenced that, to use a dosage of 100 ppm of RVO, 84.88% and 15.65% of Cpy and Py recoveries were obtained, while with a dosage of 30 ppm for BS, the recoveries were 40.96% and 14.17%, respectively. The XPS results indicated that when the minerals are treated with RVO, carbon is increased on the surface, mainly associated with C-C and C-H bonds from long hydrocarbon chains, with this phenomenon being more pronounced for Cpy. On the other hand, when treated with BS, an increase in oxygen on the surface is highlighted, along with the prominence of C=O bonds. The above is mainly for Py, as the oxygen in this case reaches 95.03% atomic percentage, while for Cpy, it does not exceed 31.90%. This could indicate possible oxidation in Py surface, which could lead to a reduction in its hydrophobicity.

Join work with C. Rodriguez (Universidad de Talca), C. Moraga (Universidad de Talca), M. Caramantín (Universidad de Talca), L. Reyes-Bozo (Universidad Autonoma de Chile) and L. Uribe (Universidad de Talca).

Estudiante PhD Juan Barajas (Universidad del Bío-Bío.)

Título: Invariant-region-preserving central WENO schemes for one-dimensional multispecies kinematic flow models

Resumen:
Multispecies kinematic flow models are defined by systems of N strongly coupled, nonlinear first-order conservation laws, where the solution is a vector of N partial volume fractions or densities. These models arise in various applications including multiclass vehicular traffic and sedimentation of polydisperse suspensions. The solution vector should take values in a set of physically relevant values (i.e., the components are nonnegative and sum up at most to a given maximum value). It is demonstrated that this set, the so-called invariant region, is preserved by numerical solutions produced by a new family of high-order finite volume numerical schemes adapted to this class of models. To achieve this property, and motivated by [X. Zhang, C.-W. Shu, On maximum-principle-satisfying high order schemes for scalar conservation laws, J. Comput. Phys. 229 (2010) 3091–3120], a pair of linear scaling limiters is applied to a high-order central weighted essentially non-oscillatory (CWENO) polynomial reconstruction to obtain invariant-region-preserving (IRP) high-order polynomial reconstructions. These reconstructions are combined with a local Lax-Friedrichs (LLF) or Harten-Lax-van Leer (HLL) numerical flux to obtain a high-order numerical scheme
for the system of conservation laws. It is proved that this scheme satisfies an IRP property under a suitable Courant- Friedrichs-Lewy (CFL) condition. The theoretical analysis is corroborated with numerical simulations for models of multiclass traffic flow and polydisperse sedimentation.
The presentation is based on ongoing research done jointly with R. Burger (CI2MA-UDEC), L-M Villada (Universidad del Bío-Bío) and Pep Mulet (Universitat de València, Spain).

Dr. Raimund Bürger (Universidad de Concepción.)

Título: The effect of bias flow and numerical simulation of the transport of liquid components in a model of a flotation column

Resumen:
This contribution presents results of ongoing research for a one-dimensional model of a flotation column that includes the effect of liquid drainage through the froth. The model consists of two partial differential equations for the bubble (aggregate) and gangue solids volume fractions, respectively, and includes a spatially discontinuous convective flux, singular source terms, and a degenerate diffusion term describing capillarity.

The presentation will be focused on two related aspects concerning the addition of wash water, which is a small amount of water is sprinkled onto the top of the froth or is injected into the froth. The introduction of wash water assists with the rejection of entrained impurities (slimes), tends to increase froth stability, and contributes to better recovery. A part of the wash water overflows with the froth bubbles and the remaining part flows down the froth counter-current to the gas phase and is referred to as bias water. In the flotation literature a net downward flow of water through the froth is usually referred to as “positive bias.” This is a desirable condition from the applicative point of view since little or no water from the feed (below the froth level) reports to the froth product.

In the first part of the presentation it is demonstrated that the “positive bias” in a determined zone of the flotation column coincides with the mathematically derived condition for the existence of a stationary bubble concentration profile, including a stable froth layer. It is demonstrated how steady-state solutions to the governing model can be constructed and conditions for their existence conveniently be mapped through so-called “operating charts.”

In the second part the construction of numerical schemes for the solution of the transient governing model is addressed. The novel assumption is that the liquid phase is subdivided into a number of components whose degree of presence is described by a vector of percentages (i.e., a vector-valued unknown function of space and time whose components are nonnegative and sum up to one). In particular, we associate one liquid component with each of the liquids that enter the column through the feed inlet, the wash water inlet, and the liquid initially present in the column. A numerical scheme for the propagation of these percentages is presented and proven to produce solutions that are nonnegative and sum up to one. The scheme can be used to follow these liquid feed streams. The numerical and mathematical treatment is, in fact, independent of the number of liquid components and could be employed to follow the transport of contaminants, reagents, or slimes. Steps of the mathematical analysis and a limited choice of numerical examples are presented.

The presentation is based on ongoing research done jointly with Stefan Diehl (Lund University, Sweden), María del Carmen Martí (Universitat de València, Spain) and Yolanda Vásquez (Universidad Tecnológica de Panamá, Panama City, Panama).

Estudiante PhD Pablo Cabrera (Universidad de Concepción)

Título: Diseño y Simulación de un Reactor de Alta Velocidad para la Aglomeración de Minerales Finos en Presencia de Óxido de Polietileno (PEO).

Resumen:
Generalmente, el proceso de floculación para la separación sólido-líquido se lleva a cabo a bajas tasas de cizallamiento. Sin embargo, en el presente estudio, se abordó el uso de reactores de ultrafloculación a altas tasas de cizallamiento para lograr la aglomeración y posterior flotación de partículas ultrafinas de minerales concentrados de cuarzo, calcopirita y molibdenita. Se utilizó óxido de polietileno (PEO) como reactivo químico para mejorar la efectividad del proceso, ya que ha demostrado ser eficiente en la recuperación de ultrafinos. A través del uso de técnicas experimentales y simulaciones de Dinámica de Fluidos Computacional (CFD), se diseñó y fabricó un reactor de ultrafloculación impreso en 3D con una capacidad de aproximada de 2.1 L para su posterior uso como etapa preliminar en experimentos de flotación en celdas de laboratorio. Las pruebas realizadas revelaron un alto grado de similitud entre las simulaciones y los experimentos en variables como la tasa de caudal y la caída de presión. Además, se obtuvieron resultados favorables en la recuperación de los minerales analizados al interior del equipo. A través de estos estudios se puede demostrar que el empleo de altas tasas de cizallamiento por periodos muy cortos de tiempo podría mejorar varios parámetros de gran relevancia en la aglomeración de partículas muy finas de minerales valiosos.
Trabajo en Colaboración con Leopoldo Gutiérrez (Universidad de Concepción)

Dr. Luver Echeverry (Universidad de Concepción)

Título: Simulación dinámica molecular de la extracción de lantano utilizando un solvente eutéctico profundo

Resumen:
En respuesta al creciente interés por sistemas de extracción más sostenibles, los solventes eutécticos profundos (DES) han surgido como una alternativa prometedora a los reactivos convencionales en la recuperación de metales. Este trabajo se centra en investigar la extracción de lantano en solución de ácido sulfúrico mediante el empleo de un DES, utilizando simulaciones de dinámica molecular (MD). Se exploraron las características estructurales del solvente y sus interacciones con los componentes de la solución acuosa. En esta investigación se diseñó un solvente eutéctico profundo a base de bromuro de tetraetilamonio (TEABr). Según los resultados de las simulaciones MD, se destacan las interacciones primarias entre los pares OG-La (4.9 Å) y CM-La (4.4 Å). Se evidencia que, al aumentar la temperatura de 25 a 80 °C, la distancia de interacción entre el par CM-La disminuye a 2.4 Å, sugiriendo una posible correlación con el aumento en la extracción de lantano, corroborado experimentalmente, este trabajo destaca la importancia de comprender las interacciones estructurales fundamentales entre el DES y la solución ácida de lantano, proporcionando una base teórica esencial para investigaciones experimentales futuras.

Dra. Lina Chica Osorio (Universidad de Medellín, Colombia.)

Título: Control de la operación de un hidrociclón desde una aproximación energética

Resumen:
El hidrociclón es un equipo de uso extendido en la industria del procesamiento de minerales debido a su versatilidad y bajo costo. Sin embargo, aún se desconocen algunos aspectos relacionados con su operación debido a la complejidad hidrodinámica. Aunque existen numerosos estudios que han intentado comprender los fenómenos que explican la separación por tamaños, muy pocos han abordado la perspectiva energética. A partir de un balance de energía mecánica enfocado en los términos disipativos, se determinan algunos parámetros claves en el control de la operación del equipo: relación geométrica (du/do), partición de caudales (Qu/Qo) y el ángulo de la descarga. Así mismo, se encuentra la existencia de regiones de descarga tipo spray y tipo rope, separadas por un valor invariante de disipación de energía mecánica específica equivalente a 1000 watt/m3. Esta información es valiosa en el control de la operación industrial de baterías de hidrociclones.

Dr. Fernando Betancourt (Universidad de Concepción)

Título: Coupled finite volume methods for settling in inclined vessels with natural convection

Resumen:
A widely applied technology of gravity-driven solid-liquid separation in mineral processing is the use of lamella settlers. These units are continuously operated tanks equipped with a number of parallel inclined plates immersed in the mixture to be separated. The inclination of the plates exploits the well-known Boycott effect that describes the enhancement of settling rates beneath inclined surfaces. This effect is usually attributed to a rapidly upward-streaming layer of clear liquid. The essence of this effect can be studied by examining gravity settling in an inclined tube or rectangular channel. The lower and upper surfaces of the channel represent the plate onto which the particles start to settle and below which the clarified liquid streams upward, respectively. In addition, an increase of temperature in some part of the fluid causes a local change in the density of the fluid and circulation of the fluid within the vessel. It has been proposed to exploit this behaviour to accelerate the settling process by additional heating. To examine this hypothesis a model and corresponding numerical method to describe inclined settling enhanced by natural convection are formulated. The model consists in a two-dimensional scalar conservation law for the solids concentration coupled with a version of the Stokes system that accounts for density fluctuations in the mixture enhanced by a Boussinesq approximation of the effect of temperature. In addition, a convection-diffusion equation describes heat transport and diffusion. The main outcome is a numerical method that allows one to simulate the effect of controllable parameters such as the initial concentration, difference of temperature, and angle of inclination on the progress of the solid-liquid separation. Numerical examples are presented. Results reconfirm that the enhancement of settling rates depends critically on the dimensions of the settling vessel, intensity of heating, and particle size, and is marginal for settling of relatively large particles and channels with a moderate length to width aspect ratio.
This is a joint work with Julio Careaga (UBB), Raimund Bürger (UDEC) and Lucas Romero (UDEC)

Dr. Andres Ramirez (Universidad de Concepción)

Titulo: Acondicionamiento de burbujas como una alternativa para mejorar la flotación de minerales sulfurados de cobre y molibdeno.

Resumen:
El proceso de flotación es una técnica que mezcla la fisicoquímica de superficies de sistemas particulados y la fluidodinámica para realizar la concentración de minerales de interés. En este proceso conviven sólidos, líquidos y gas (burbujas). Actualmente, el acondicionamiento se a enfocado en los sólidos y el líquido, dejando la fase gaseosa, por lo general, sin procesos de acondicionamiento. El objetivo de este trabajo fue evaluar la posibilidad de utilizar la técnica conocida como oily bubbles para mejorar la recuperación de minerales sulfurados con alto grado de hidrofobicidad natural e inducida en diferentes medios acuosos. Se encontró que esta técnica permite mejorar la flotabilidad de las partículas de interés, aumentando la recuperación de la molibdenita hasta en 10 puntos porcentuales en agua de mar a pH alcalino y hasta de 15 puntos porcentuales para la calcopirita en ambientes similares en micro celda de flotación. El escalamiento de esta técnica ha permitido tener mejores condiciones de flotación para calcopirita y molibdenita en celda de flotación de 2.7 litros y de 40 litros, utilizando mineral real y manteniendo las dosificaciones de los reactivos con las que previamente se optimizó la flotación del mineral sin acondicionar las burbujas.
Trabajo en colaboración con Andres Ramirez, Leopoldo Gutierrez, Luver Echeverry.

Mapa del Lugar