Aurubis AG

Metals for Progress

Summary of Aurubis organised 3rd Minor Metal Symposium:

Multi Metal Management and Sustainable Processing of Complex Sulfide Materials

Lisbon, October 23st, 2019
Agenda

1. Symposium set up
2. Key takeaways
3. Way forward
3rd Minor Metal Symposium organised by Aurubis in collaboration with the ICSG in Lisbon

» First one organized by Ecometales in Chile in 2017

» Second organized by JOGMEC in Japan in 2018

» This year symposium set up of four consecutive open discussion panels representing
  » Mining
  » Smelting
  » Research Institutes
  » Technology providers

» Specific guidelines specifying content and questions to be answered issued to all panelists to keep discussions focused

» Technical Moderators related to the various industry sectors chosen
  › Joe Pease, Mineralis Consultants- Mine & Concentrator Panel
  › Nakashi Takamura, University of Tokyo- Smelters Panel
  › Christina Meskers, Umicore- Research Institutes Panel
  › David Dreisinger, University of British Columbia- Technology Panel
Very strong turn out confirms the importance of the topic to the Industry

75+ attendees from across the metal processing industry

16 panelists

Global representation with an important European presence

Ambitious agenda

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<td>08:15</td>
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| 08:45  | **Panel 1:** Understanding potential synergies from the mining side: how to ensure effective collaboration between miners and smelters to improve overall metal recovery  
Carlos Risopatron, Director of Economics and Environment, International Copper Study Group (ICSG)  
Joe Pease, Principal Consultant, Minerals Australia  
Jorge Curral, Director Process Seminor, Lundin Mining  
Raul Benavides, Vice President Business Development, Buenaventura  
Liangmin Gu, Deputy Managing Director, Minmetals UK  
Chris Fountain, Chief Advisor, RioTinto |
| 09:10  | **Motivation 1:** Mine & concentrator challenges to meet concentrate quality  
Joe Pease, Principal Consultant, Minerals Australia |
| 09:30  | **Panel 1:** Understanding potential synergies from the mining side: how to ensure effective collaboration between miners and smelters to improve overall metal recovery  
Carlos Risopatron, Director of Economics and Environment, International Copper Study Group (ICSG)  
Joe Pease, Principal Consultant, Minerals Australia  
Jorge Curral, Director Process Seminor, Lundin Mining  
Raul Benavides, Vice President Business Development, Buenaventura  
Liangmin Gu, Deputy Managing Director, Minmetals UK  
Chris Fountain, Chief Advisor, RioTinto |
| 10:45  | Coffee break                                                             |
| 11:00  | **Motivation 2:** Smelters and refineries strategies to mitigate impact of minor metal increase in feed  
Dr. Markus Reuter, Helmholtz-Institute Freiberg for Resource Technology |
| 11:20  | **Panel 2:** Sustainable multi metal processing in copper, lead and zinc smelting and refining operations  
Arturo Vaca, Vice President Energy and Technology, Met Mex Perúlos  
Dr. Adalbert Lossin, Executive Director R&D, Aumühle AG  
Dr. Yoshitsugu Miyabayashi, Senior Executive Officer, General Manager, Metals Division, JX Nippon Mining & Metals  
Dr. Guillermo Rios, Technology Director, Atlantic Copper |
| 12:45  | Lunch break                                                              |
| 13:45  | Lunch break                                                              |
| 14:20  | **Motivation 3:** The Role of Research and Technology to manage minor metals  
Dr. Juan Carlos Salas, Pontificia Universidad Catolica de Chile |
| 14:40  | **Panel 3:** Fundamental research and innovation to support development of sustainable solutions for the management of deleterious elements  
Dr. Roberto Parra, Universidad de Concepcion, Chile  
Dr. David Dreisinger, University of British Columbia, Canada  
Prof. Neville Plint, University of Queensland, Australia  
Dr. Gert Homm, Fraunhofer Institute for Silicate Research, Germany  
Dr. Etsuro Shibata, IMRAM, Tohoku University, Japan |
| 16:15  | Coffee break                                                             |
| 16:30  | **Panel 4:** Holistic approach to develop and integrate technological solutions to mitigate the impact of deleterious elements in the production of base metals  
Dr. Ilkka Kojo, Senior Advisor Technology, Outotec  
Ivan Valenzuela, General Manager, Ecometales  
Tom Gonzalez, Director Copper Associate, Hatch |
| 17:45  | Concluding remarks                                                       |
| 18:30  | Networking with participants and speakers                                 |
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Collision of tighter smelter restrictions with increasing ore complexity

- Lower in grades
- Higher in impurities
- Sustainability requirements
- Increased regulatory requirements

Source: ICSG, 2019 Minor Metal Symposium, Lisbon

*ICSG Reported Global Imports of Copper Concentrates in Gross Weight kt*

*Industry grades continue to decline*

Weighted average copper grade¹, %

Source: Australia Bureau of statistics 2017
Coordinated Industry approach more effective than solutions in Silos

» Need for technical dialogue and collaboration between various industry sectors

» Lower grades can be improved in many cases by adopting existing modern technologies on concentrators—already being done (Prominent Hill and Salobo)
  » Froth washing (removing entrained non sulphide materials)
  » Fine regrinding

» This will in many cases also decrease impurity load associated with minerals (CaF2, FeAsS2, UO)

» Additional capital and operating costs- need economic justification

» Need the right market signals to reflect true cost of removing impurities:
  » Metal grade incentive
  » Penalty per tonne of impurity produced

Adapt commercial arrangements (concentrate contract) to reflect current realities of social and environment requirements
Some impurities cannot be removed at mineral level—will require extractive metallurgy process.

Solutions do exist and continuously being optimized (roast, leach).

Can be implemented at site or in a central facility.

- Mine site preferable place to store impurity in most cases.
  - Particularly true when no market outlet available.

Need to standardize waste characterization tests and apply best practices for residue disposal:

- Industry program under an independent body.

Focuses on the safe management and disposal of As.

Development of Arsenic Code similar to the existing Cyanide code.
Coordinated Industry approach more effective than solutions in Silos ctd…

- European smelters affected by changing complexity of ores
  - Slag produced is a product for sale (not stored) so need to meet specific criteria
  - Creates a restriction in terms of feed that can be treated

- Industry driven collaborative program between smelters and research institutes

Need for a slag working group

- Develop technology to ensure slag is a marketable product
Various institutes presented working models

- Collaboration between industry and Research Institutes on national and international level

Industry need to clearly articulate the challenge for an effective value proposition to be generated

Importance of transparency & digitalisation to attract the next generation of professionals

- Industry driven programs between Smelters and Miners and research Institutes

- Multi-Disciplinary approaches more effective

Need clear statements on the tasks, problems and targets to be solved
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Brink of a new “electrical” revolution: collaboration is key for the future of the industry and the users

- Minor metal symposiums to be continued in 2020 (annually)
  - 4\textsuperscript{th} organizer and location still to be determined
- Need involvement of the Chinese mining industry + Others- Global community needed for this global challenge
- **Key action points for solutions** to be agreed and progress presented at the next symposium on minor metals in base metal concentrates
- Industry attendees agreed to work on:
  - codes to manage some minor metals at a global scale, starting with Arsenic.
  - Initiating a slag working group