Challenges in Implementation of Highly Thickened Tailings Technology in Large Production Volumes

Panel Discussion
Friday July 8, 2016
Chairman: Luis Valenzuela

- Civil Engineer, Universidad de Chile
- MSc in Geotechnics, Imperial College, London
- Geotechnical Consultant, formerly at ARCADIS
- Former Vice President of the ISSMGE
- Almost 35 years dealing with tailings deposits as designer, reviewer and consultant in Chile, Peru, Argentina and Canada.
- More than 30 papers and conferences on tailings
- In 2015 delivered the Casagrande Lecture on “Hydraulic Fill and Sand Tailings Dams”.
The development of the HDTT

• Almost 50 years ago Eli Robinsky (1968) proposed what was thought at that moment the final solution for tailings deposits: Thickened Tailings (TT).

• A solution without the need of a dam to contain the tailings and allowing to recover more water close to the processing plant was extremely attractive.

• After many intents (some successful and many frustrating ones), a more significant progress in the understanding of the mechanics and the rheology of thickened tailings as well as in the development of thickeners and pumps started around 2000.

• The history of PASTE conferences has contributed to the discussion of TT and Paste, encouraging the share of experience.
What happened in all these years?

- The TT and High Density TT (HDTT) have been applied with relative success in relatively small to medium size operations.
- Several difficulties have been encountered when dealing with large production volumes.
- The final result is **uncertainty** in the prediction of actual behavior of large volumes of tailings, in aspects such as beach slopes, pumping difficulties, thickeners performance and others factors impacting in the actual water recovery and operational problems.
- **Uncertainty finally represents risk** which in some cases could be considered excessive.
Questions put to the Panelists

• Is the currently available thickening technology suitable for treating variable tailings to high Cp?
• Are thickener control systems currently appropriate? Or, in other words, are the operators able to safely manage and control the thickening operation?
• Are the tailings transport systems able to adapt to significant variations in consistency/yield stress?
• Could it be that the thickened tailings management approach has not been addressed in a holistic manner?
• What should be the main driver(s) in the design of a system of thickened tailings?
• Is it possible or expected to have a reliable process at high thickening rate in the close future?
Panel discussion scheme (8:20 – 10:00)

• Introduction by the Chairman: 9 minutes
• Responses to the questions by the 4 panelists: 9 minutes each total 36 minutes
• Open floor discussion total 38 minutes
• Panel closing by the 4 panelist 3 minutes each total 12 minutes

Final words by the Chairman 5 minutes
Invited panelists

- **Gonzalo Caro**, Director of Thickened Tailings, Talabre, CODELCO, Chile.
- **Fred Schoenbrunn**, Global Director for Thickeners, FLSmidth Minerals, USA.
- **Marco Becerra**, General Manager, ASMIN, Chile
- **Christian Kujawa**, Process Manager, Paterson & Cooke, USA.
Panelist Mr. Gonzalo Caro

- Civil Engineer, Universidad Tecnica, Valparaíso, Chile.
- Applied Soil Mechanics graduate work, Universidad de Chile.
- 12 years of experience in mining projects.
- Specialized in Thickened Tailings and Paste Tailings deposits.
- Project Director Thickened Tailings System at Talabre deposit in Chuquicamata. Projects Vice Presidency of CODELCO, Chile.
Panelist Mr. Fred Schoenbrunn

• Chemical Engineer, Lehigh University
• Professional Engineer (PE).
• Director for Thickeners at FL Smidth.
• Expertise and research interest in development of thickeners, deep cone and paste thickening.
• Particular experience on design of large and HDT Thickeners.
Panelist Mr. Marco Becerra

- Civil Engineer (Metallurgy). Universidad de Santiago USACH, Chile.
- More than 30 years of experience.
- For 18 years worked at EIMCO as Process Engineer, Product Manager and Sales Manager. Chile, Mexico and Peru.
- In 2003 founded ASMIN. General Manager.
- Consultancy, lab and pilot tests on thickened tailings for the main mines in Chile.
Panelist Mr. Christian Kujawa
One question from the Chairman

• We have been discussing the uncertainty in the prediction of many variables associated to TT and HDTT.
• At the same time most of the figures and data that is shown in most of papers and even in most of designs are deterministic values.
• Don´t you think that a probabilistic approach should be the right (and honest) way to deal with phenomena subject to many uncertainties and possible variations and deviations?
The right way to communicate?

- \( Cp = 67\% \) or \( Cp \) range = 61\% - 68\%?
- Yield Stress = 15 Pa or YS range = 12 – 20 Pa?
- Water recovery 70\% or WR range 50\% - 70\%?
- Rump up 6 months or range of 6 to 12 months?
- What are the probabilities associated?
- Which is the impact on the project of different possible scenarios?
- TT don’t fail? or TT could fail under some circumstances (Probability? Mitigations?)
- When TT shouldn’t be recommended or considered?
Desafíos en la implementación de la tecnología de relaves altamente espesados en grandes producciones

Gonzalo Caro P.
Codelco VP, Chile
Preguntas

• ¿Es la tecnología de espesamiento actual adecuada para tratar relaves con una variable alto contenido de sólidos?
• ¿Los sistemas de control de los espesadores son apropiados? O, en otras palabras, ¿son los operadores capaces de controlar de manera segura la operación de espesamiento?
• ¿Están los sistemas de transporte de relaves preparados para adaptarse a las variaciones significativas en la consistencia / tensión de fluencia?
• ¿Es posible que el enfoque de gestión de relaves espesados no haya sido abordado desde un punto de vista integral?
• ¿Cuál debe ser el motor principal, factor en el diseño de un sistema de relave espesado?
• ¿Es posible o esperable alcanzar un proceso confiable de alta tasa de espesamiento en el futuro cercano?
Copper mining process
Mine Geology
Block model mining
Statistic analysis
3d modelling & Geostatistics

Variogram \( y(h) \)

\[
\gamma(h) = \frac{1}{2Np(h)} \sum_{i=1}^{Np(h)} [Z(x_i) - Z(x_i + h)]^2
\]

\[
\gamma(h) = \frac{(1-1)^2 + (1-3)^2 + (1-3)^2}{2+3} = 1.0
\]

\[
\gamma(2h) = \frac{(1-3)^2 + (2-3)^2}{2+3} = 0.25
\]

\[
\gamma(3h) = \frac{(1-9)^2}{2+3} = 2.0
\]

\[
\gamma(h) = \begin{cases} 
    C_0 + C_1 [\frac{(32)(h/a)}{1 + \gamma(h/a)^2}] & h \leq a \\
    C_0 + C_1 + C_2 + C_3 & h > a
\end{cases}
\]
Resources estimation
From resources to reserves
Mine planning
Copper mining process
Conclusions

• High thickening process must be integrated in mine planning.
• Restrictions in thickening process can affect mine business.
• Thickening process must be predictable and daily planified from mine extraction and concentrator feed.
Thanks!
High Tonnage, High Density Thickening - Challenges

Fred Schoenbrunn
Director of Thickeners
FL Smidth
12 x 24 m DCT, 96,000 tpd
## Relative Costs

<table>
<thead>
<tr>
<th>Thickener Type</th>
<th>Relative Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Rate Thickener</td>
<td>1.0</td>
</tr>
<tr>
<td>High Density Thickener</td>
<td>1.3x</td>
</tr>
<tr>
<td>Deep Cone Thickener</td>
<td>2.0x</td>
</tr>
</tbody>
</table>
Technical Challenges for Thickeners

• High Torques
  – Bigger drives
• Floor Slope
• Rake Designs
  – Different Loading Criteria
  – Raking Efficiency
  – Low Drag Truss
    • High Strength Steel
    • Low Profile Members
  – Tubular Designs
Other Challenges

• Difficult to Specify, But Buy on Lowest Cost?
• Matching Thickener Performance to Pumping system
• System Control
• Communication
• Design for Single Point Maximums
• Industry Risk Aversion
Suitability

• Economy of scale plants
  – Driver is cost reduction
    • Requires reliability in terms of throughput and availability
    • Requires reduction in number of units
  – Less selective mining

• HD and PT constitute an incremental technology change, have not undergone major redesign
Control

• Degree of control required
• Underflow solids concentration
  – Wrong measure
  – Require reliable on-line rheometer
• Yield stress reduction
• Un-coupling of thickening and pumping
Transport

• Large flows of settling slurry
  – The larger the pipe diameter the higher the required flow velocity to stay in turbulent flow
• Rheology modification
Drivers / Design for Reliability

• Variability testing
• Design practice
  – Risk analysis
  – Contingency and closed loop elements
    • Filtration
    • Rheology modification
    • EOP adjustments
  – Holistic solution
    • Engineered tailings
    • Creative flow sheet implementations
    • Overall lowest cost