Optimizing the Process with Metso CISA

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Optimizing the Process with Metso CISA

Metso CISA Team
Metso CISA Technologies by process

Advanced Process Control
About Optimizing Control System
VisioFroth™ technology
  - Description of the system
  - Flotation expert control
  - Example of VisioFroth™ installation and its benefits

VisioRock™ technology
  - VisioRock™ applications
  - Description of the system
  - Example of VisioRock™ installation and its benefits

CISA/Microcel™ Flotation Columns
  - About flotation columns
  - Description of CISA/Microcel™ sparger system
  - Example of sparger retrofit and its benefits

Questions
Metso CISA Team

• Worldwide technical and development center in Orleans, France
• Offices in Salt Lake City (USA), Santiago (Chile), Belo Horizonte (Brazil) and Australia
• Team of experts dedicated to the optimization of mineral processes for over 20 years, by developing and providing
  ▪ Renown expertise and efficiency
  ▪ Robust state-of-the-art software solutions
  ▪ Industrially proven hardware
  ▪ Short payback time through high benefits

Metso CISA product lines
• Advanced Process Control Solutions & Sensing Systems
• High Recovery Flotation Columns
Metso CISA technologies by process
Mining, ore handling and screening

VisioTruck™
VisioRock-Studio©
VisioRock™ OversizeDetector
ImageMiner™
Metso CISA technologies by process

Crushing and grinding

Advanced sensing systems:

- VisioRock™
  
  (over 100 cameras)
- AudioMill™
  
  (close to 15 sites)
- VisioBall™

Advanced control systems:

- Expert System
- Dynamic Model
- Optimizer
- MPC

Process Control Simulator

ImageMiner™

Navigator™
Metso CISA technologies by process

Flotation, separation, thickening

Sensing systems:
• VisioFroth™ (more than 1300 cameras)
• LaserFroth™

Advanced control system:
• Expert System
Process Control Simulator

ImageMiner™; Navigator™

CISA /Microcel™
Columns and sparger systems
(close to 200 columns)
Optimizing the Process with Metso CISA

Advanced Process Control
Optimizing control system

Optimizing Control System

- On line optimization of set points
- Search for maximum profit

DCS or PLC/SCADA

- Regulatory control
- Operator Interface

Instrumentation

Process

OBJECTIVES
- Increased tonnage, recovery, and quality
- Lower operating costs (energy, reagents, grinding media)
OCS© Optimizing Control Software

- Expert System with Fuzzy Logic
- Statistics Trending
- Historian
- HMI
- Optimizers
- Advanced Controllers
- Soft Sensors
- Neural Network
- Acoustics
- Vision
- Optimizers
- Statistics Trending
- Historian
- HMI
- Optimizers
- Advanced Controllers
- Soft Sensors
- Neural Network
- Acoustics
- Vision

Plant with DCS / PLC-SCADA

Measurements

Setpoints
VisioFroth™ technology

Description of the system
Froth velocity control
VisioFroth™: description of the system

Vision system consists of:

- Cameras installed at critical locations in the process
- IP (network cameras)
- Lighting system
- One or more computers linked to the cameras
- Software (OCS© or OCS-4D ©) that analyses the images in real time and generates valuable information
VisioFroth™: description of the system

Principle

Key measurements

- Froth Velocity
- Bubble Size
- Color
- Texture
- Collapse rate
- Stability
- Load
- Froth thickness (option)
- …
VisioFroth™ and expert control
Froth velocity control diagram

**PROCESS**
- Dart valve opening/closing
- Air flow control valve opening/closing
- Frother pump speed
- Collectors pumps speed

**DCS/PLC**
- Cell pulp level
- Air flow
- Concentrate sump level
- Concentrate grade
- Tailings grade

**VISIOFROTH™**
- Froth velocity
- Bubble size

**Froth Velocity Control Loop**
- Air flow setpoint
- Cell pulp level setpoint
- Frother dosage

**Expert System + Fuzzy Controller**
- Concentrate sump level
- Tailings grade
- Concentrate grade

**OPERATOR**
- Collectors dosage
- Dart valve opening/closing
- Air flow control valve opening/closing
- Frother pump speed
- Collectors pumps speed

**OPERATOR**
- Dart valve opening/closing
- Air flow control valve opening/closing
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VisioFroth™ and expert control

Flotation expert control diagram

- Dart valve opening/closing
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- Cell pulp level
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DCS/PLC

- Air flow setpoint
- Cell pulp level setpoint
- Frother dosage

Expert System + Fuzzy Controller

- Concentrate sump level
- Tailings grade
- Concentrate grade

Collectors dosage

Froth Velocity Control Loop

- Froth velocity
- Bubble size

Velocity setpoint

Expert Control Loop

- Dart valve opening/closing
- Air flow control valve opening/closing
- Frother pump speed
- Collectors pumps speed

- Cell pulp level
- Air flow
- Concentrate sump level
- Concentrate grade
- Tailings grade
Example of VisioFroth™ installation at Escondida

Benefits from VisioFroth™ and associated expert system
Copper Flotation
Minera Escondida, Laguna Seca, Phase IV, Chile

• 102 VisioFroth™ cameras in 2003
  - Rougher (54 cells)
  - Cleaner (20 cells)
  - Scavenger (20 cells)
  - 2nd Cleaner (8 columns)

• OCS© also controls:
  - Regrinding (4 Vertimills)
  - 5 thickeners

• Results

  Formal ON/OFF evaluation in 2004 shows a
  1.5% increase in copper recovery
  at unchanged copper grade
VisioFroth™ References

EMEA
- Somincor, Portugal
- Nordkalk, Finland
- Nesko, Albania
- Golden Star Resources Bogoso, Ghana
- Nevsun Bisha, Eritrea
- Ozdogu, Turkey
- RTB Bor, Serbia

SAM
- Rio Tinto Paracatu Kinross, Brazil
- CMM Vazante, Brazil
- CMM Morro Agudo, Brazil
- MBR Pico, Brazil
- CSN, Brazil
- Minera Escondida Laguna Seca, Chile
- Minera Escondida Los Colorados, Chile
- Anglo Collahuasi, Chile
- Codelco Andina, Chile
- Codelco El Teniente, Chile
- Codelco El Salvador, Chile
- Antofagasta Esperanza, Chile
- Antofagasta Los Pelambres, Chile
- Freeport Candelaria, Chile
- Anglo Las Tórtolas, Chile
- Universidad F Santa Maria, Chile
- Minera San Cristobal, Bolivia
- Antamina, Peru

NAM
- Rio Kennecott Copperton, Utah
- Brunswick, Canada
- Freeport Bagdad, USA
- Freeport Sierrita, USA
- Freeport Climax, USA
- Thompson Creek Mount Milligan, Canada
- Teck Red Dog, Alaska
- PCS Allan, Canada
- Newmont Phoenix, USA
- Newmont Carlin, USA
- Omya, Alabama
- Teck Highland Valley Copper, Canada
- Teck Pogo, Alaska
- Omya Perth, Canada
- Shell Albian Sands, Canada
- Hecla GreensCreek, USA
- Kemess, Canada (retrofit)

APAC
- Newcrest Hidden Valley, Papua New Guinea
- Newcrest Telfer, Australia
- Rio Tinto Northparkes, Australia
- Barrick Cowal, Australia
- BMA Peaks Down, Australia
- BMA Caval Ridge, Australia
- Newmont Boddington, Australia
- Newmont Boddington, Australia
- Newmont Batu Hijau, Indonesia
- Freeport PTFI, Indonesia
- HZL Rampura Agucha, India
VisioRock™ technology

VisioRock™ applications

Description of the system
VisioRock™ applications

• Either standalone instrument or a component of an integrated advanced control system

• Traditional applications of rock size measurement:
  - SAG/AG mill feed / SAG mill control
  - Crusher product / Crusher gap control
  - Apron Feeder management

• Innovative applications:
  - Screen undersize monitoring (OversizeDetector)
  - Detection of large objects (OversizeDetector) for equipment protection
  - VisioTruck™ for truck load measurement

• Ore type identification (by size, color, texture)
VisioRock™: description of the system

Hardware

Light shielding

VisioRock™ lighting system

VisioRock™ camera with air barrier system
Example of VisioRock™ installation at Ahafo

Benefits from VisioRock™ and OCS© expert system
Disturbances
• Changes in ore type, hardness, size
• Segregation in the stockpile
• Availability of oxide ore
• …
Newmont Ahafo, Ghana

Components of APC System

- Expert system with fuzzy logic and optimizing control strategy
- Soft sensor (estimates key process variables)
- VisioRock™ rock size measurement over SAG mill feed
- AudioMill ™ to analyse SAG mill sound
Newmont Ahafo, Ghana

VisioRock™

• One camera over primary crusher product
  - PSD measurement
  - Mine to mill optimization

• One camera over fresh feed
  - 13 size classes from -6mm to +225mm
  - Estimates proportion of “Rocks”, “Pebbles” and “Fines” in fresh feed as inputs for the soft sensor
  - Essential for feedforward control of the SAG mill
  - Check the efficiency of the manipulation of apron feeder n°3 (which deliver coarser particles)
    • High SAG mill mass → delivery of fine particles
    • Low SAG mill mass → delivery of coarser particles
Newmont Ahafo, Ghana

Grinding control system performance

• OCS© controls the plant 96% of the time (Dec 2010 – May 2011)
• Integrated system, with OCS© hosting expert system, soft sensor, VisioRock™ and AudioMill™, with one computer only
• Well informed control strategy, with both feedback and feedforward control
• Circuit operating at a physical constraint 95% of time:
  - 26% SAG mill limited (22% mill mass, 4% pebbles tonnage)
  - 69% ball mill limited (53% circulating load)
• **3.3% increase in gold production**
  - **2.8% increase in recovery** from better PSD control
  - **1.1% increase in tonnage**
• Results presented in SAG 2011 in Vancouver
VisioRock™ References

Australia
Rio Tinto Pilbara Iron Paraburadoo, Australia
Rio Tinto Pilbara Iron Tom Price, Australia
Rio Tinto Northparkes, Australia
BHP Cannington, Australia
Prominent Hill, Australia
McArthur River, Australia
Goldfields St. Ives, Australia
ERA Ranger Uranium, Australia
Gemco, Australia
Yandi, Australia

South and North America
Newmont Phoenix, USA
Antamina, Peru
Newmont Yanacocha, Peru
Minas de Toquepala, Peru
Minera Escondida Los Colorados, Chile
Minera Escondida Laguna Seca, Chile
El Teniente, Chile
Peñoles Fresnillo, Mexico
Sermmosa, Mexico
Freeport Climax, USA

Africa
Rio Tinto Palabora, South Africa
Anglogold Ashanti Semos Sadiola, Mali
Goldfields Tarkwa, Ghana
Debswana Jwaneng, Botswana
Letseng Diamond, Lesotho
Newmont Ahafo, Ghana
Iamgold Essakane, Burkina

Europe
Roy Aggregates, France
Carrières de Trapp, France
Carrières de la Loire, France

Retrofits of existing systems:
Freeport La Candelaria, Chile
RPM Rio Paracatu Mineração, Brazil
Minera Los Pelambres, Chile
Kennecott Copperton (test), Utah USA
Minera Escondida Laguna Seca, Chile
MKS, USA
Freeport PTFI, Indonesia
Kemess, Canada
Optimizing the Process with Metso CISA

CISA/Microcel™ Flotation Columns
About Flotation Columns

General description of operation
History of sparging technology
About flotation columns

General description of operation

• Used to perform mineral separation
• Columns do not use mechanical agitation (impellers)
• Instead, mixing is achieved through turbulence provided by rising bubbles
• Mostly used to produce final grade concentrates because of high selectivity
• Differences with mechanical cell:
  - Shape
  - Bubble generation system
  - Use of wash water
About flotation columns

History of sparging technology

<table>
<thead>
<tr>
<th>Porous spargers</th>
<th>Air-only spargers</th>
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</thead>
<tbody>
<tr>
<td><img src="image1" alt="Porous spargers diagram" /></td>
<td><img src="image2" alt="Air-only spargers diagram" /></td>
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</table>

<table>
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<th>Air-water spargers</th>
<th>CISA/Microcel™ spargers</th>
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<tr>
<td><img src="image3" alt="Air-water spargers diagram" /></td>
<td><img src="image4" alt="CISA/Microcel™ spargers diagram" /></td>
</tr>
</tbody>
</table>
Microcel™ Sparger System

Description of Microcel™ technology
CISA/Microcel™ flotation column

Slurry feed

Froth concentrate

Collection zone

Tailings discharge

Microcel™ Sparger System
CISA/Microcel™ flotation column

Sparger system description
CISA/Microcel™ flotation column

Sparger system description

- Slurry inlet
- Sparger isolation valve
- Air inlet
- Static mixer
- Air + slurry discharge
An example of sparger system retrofit

Comparison between air-only and Microcel™ system at Antamina Mine
Sparger retrofit at Antamina

Copper flotation circuit

Feed → Copper roughers (3 x 7) → Tower mills (x 2) → Cyclones (2 x 17) → Copper scavengers (1 x 5) → First copper cleaner columns (1 x 4) → Second copper cleaner columns (1 x 4) → Bulk copper concentrate → To zinc circuit
Sparger retrofit at Antamina

Molybdenum flotation circuit

Bulk copper concentrate → Moly roughers (12) → Final copper concentrate

Moly scavengers (4) → First moly cleaner column → Second moly cleaner column → Third moly cleaner column → Moly concentrate
Sparger retrofit at Antamina

Bubble viewer developped at McGill University

- McGill University bubble viewer and image analysis software
- Measured bubble diameter is used to determine volume and surface area
- Bubble size expressed as the Sauter mean diameter ($d_{32}$) where:

$$d_{32} = \frac{6 \cdot \text{volume } (V_b)}{\text{surface area } (A_b)}$$
Sparger retrofit at Antamina

Bubble size measurement

Microcel™

Air-only sparger
Sparger retrofit at Antamina

Bubble size – Copper column

Air-only sparger:
\[ d_{32} = 3.2 \text{ mm} \]

Microcel™:
\[ d_{32} = 2.0 \text{ mm} \]
Sparger retrofit at Antamina

Grade vs Unit Recovery

Copper Column

Mo Recovery:

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<th>Dec 06</th>
<th>Mar 07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcel™</td>
<td>84%</td>
<td>72%</td>
</tr>
<tr>
<td>Air-only sparger</td>
<td>57%</td>
<td>36%</td>
</tr>
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</table>

Cu Column Recovery:

<table>
<thead>
<tr>
<th></th>
<th>Cu</th>
<th>Mo</th>
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<tbody>
<tr>
<td>Microcel™</td>
<td>81%</td>
<td>48%</td>
</tr>
<tr>
<td>Air-only sparger</td>
<td>75%</td>
<td>27%</td>
</tr>
</tbody>
</table>
Sparger retrofit at Antamina

Conclusions

• Improved bubble size generation
  - Cu 3.2 to 2.0 mm
  - Mo 2.7 to 1.8 mm

• Estimate of overall circuit improvement
  - Cu grade + 0.5%
  - Mo recovery + 10%

• Reduction of circulating load in overall circuit

• Improvement in operability

• A total of 9 flotation columns retrofitted between 2006 and 2008
• 2 new CISA flotation columns installed in 2010
Microcel™ Sparger System

Advantages of Microcel Sparger system
CISA/Microcel™ sparger system

Advantages

- Produces Smaller Bubbles
  - Improved Recovery in collection zone

- Smaller Bubbles in the Froth
  - More Stable Froth

- Increased froth stability
  - Deeper Froth, Higher Wash Water Flowrate

- Different operating range for froth depth and wash water rate
  - Increased Concentrate Grade
CISA/Microcel™ References

EMEA
- Boliden, Aitik, Sweden
- Boliden, Laisvall, Sweden
- Boliden, Myra Falls, Zambia
- Boliden, Apirsa, Spain
- NFC Africa, Chambishi, Zambia
- KCM, Nchanga, Zambia
- MATSA, Aguas Tenidas, Spain
- Ozdogu Insaat, Turkey
- Iscor, Rosh Pinah, Namibia
- AngloAmerican, Lisheen, Ireland
- Arcon Mines, Galmoy, Ireland
- LKAB, Kiruna, Sweden
- LKAB, Svapaaavaara, Sweden
- Tricorona, Woxna, Sweden
- Greenfield, France
- ICS, Taiba, Senegal
- NWPhCo, Russia

NAM
- Boliden, Myra Falls, Canada
- Agnico Eagle, Laronde, Canada
- Rio Tinto, Kennecott, USA
- Yukon Zinc, Wolverine, Canada
- Teck, Duckpond, Canada
- Vale, Clarabelle, Canada
- Terrane Metals, Mt Milligan, Canada
- Teck, HVC, Canada
- Rosemont Copper, USA
- Thomson Creek, USA
- Freeport, Bagdad, USA
- Adanac, Ruby Creek, Canada
- Teck, Red Dog, USA
- Hecla Mining, Greens Creek, USA
- NAP, Lac des Iles, Canada
- PCS, Allan, Canada
- Agrim, Vault, Canada

SAM
- Grupo Mexico, La Caridad, Mexico
- BHP Billiton, Tintaya, Peru
- Mineraçao Maraca, Chapada, Brazil
- Antamina, Peru
- BHP Billiton, Escondida, Chile
- Freeport, Cerro Verde, Peru
- Newmont, Conga, Peru
- Los Pelambres, Chile
- Codelco, Andina, Chile
- Penoles, Tizapa, Mexico
- Penoles, La Cienega, Mexico
- Penoles, Naica, Mexico
- Volcan, Paragsha, Peru
- Sinchi Wayra, Bolivar, Bolivia
- Penoles, Madero, Mexico
- Penoles, Sabinas, Mexico
- Penoles, Bismark, Mexico
- Vale, Timbopeba, Brazil
- Vale, Conceicao, Brazil
- Vale, Alegria, Brazil
- Gerdau Açominas, Mig. Burnier, Brazil
- Bunge, Araxa, Brazil
- Bunge, Cajati, Brazil
- Newmont, Conga, Peru

APAC
- Nicico, Sar Cheshmeh, Iran
- Nicico, Miduk, Iran
- Nicico, Sungun, Iran
- Freeport, C3/C4, Indonesia
- Philex, Padcal, Philippines
- Ivanhoe Mines, Oyu Tolgoi, Mongolia
Metso CISA technologies

To conclude

• Renowned expertise in optimization of mineral processing
• Solutions with short payback time and high efficiency by improving:
  - Recovery
  - Grade
  - Tonnage
  - Operability
  - Energy and reagents consumption
  - ...
• Flotation columns: good complement in flotation circuit (highly selective)
Thank you for your attention

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