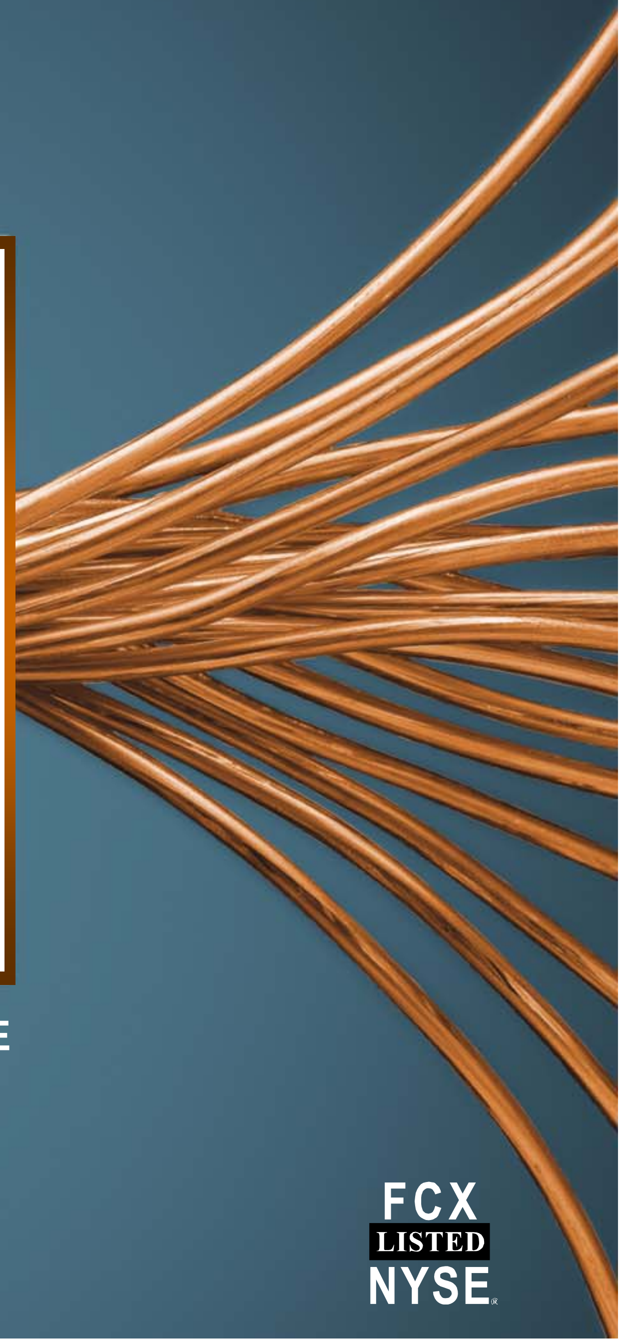
FREEPORT-McMoRAN
COPPER & GOLD

Electrolytic Copper Refining 2010 World Tankhouse Survey

Tim Robinson, Andreas Siegmund, Bill Davenport, Mike Moats and George Karcas

June 9, 2010



PROVEN PERFORMANCE
SHINING FUTURE

FCX
LISTED
NYSE

www.fcx.com

FREEPORT-MCMORAN COPPER & GOLD

Summary

- Introduction
- Regional trends
- Future projects
- Process technology
- Conclusion

Introduction

- Seventh in a series of world and regional copper electrowinning surveys since 1997
- Previous Surveys
  - 1997, 1999, 2001, 2002, 2003, 2006/07
- The data of 57 EW plants is tabulated
- Previous survey data was included

Regional Trends

- South America
- Africa
- North America
- Oceania / Asia

Regional Trends – South America

- Chile dominates the world in size and number of copper EW operations
- Peru has the first SX EW plant built in South America at Cerro Verde and has some future copper EW project potential

FREEPORT-MCMORAN COPPER & GOLD

South American EW – El Abra

FREEPORT-MCMORAN COPPER & GOLD

Central Africa

- Other region outside of the Americas where EW is prevalent is in central Africa, particularly Zambia and DRC
- Most recent large scale copper EW projects are in DRC

African EW – Tenke

FREEPORT-MCMORAN COPPER & GOLD

Regional Trends – North America

- Southwest USA, particularly Arizona, has led the world in the early evolution of copper SX EW plant design
- Newest copper SX EW plant start up is Quadra's Carlotta in Arizona, east of Phoenix
- Oldest existing copper SX EW plant in the world is at Bagdad in Arizona

North America EW – Bagdad

North America EW – Chino

North America EW – Safford

Oceania/Asia

- Largest copper SX EW plant in this region is located in Laos (Sepon)
- Several Australian SX EW plants have been shut down due to reserve exhaustion and conversion from cathode to concentrate

Asian EW – Sepon

Process Technology

- Cathode Technology
- Anodes
- Automatic Cranes
- Electrolytic Cells
- Air Sparging
- Electrolyte Additives
- Electrode Contact System
- Automated Cell Voltage Monitoring
- Mist Suppression
- Summary

Permanent Cathode Technology

- Two thirds of the respondents use permanent cathode technology as per previous surveys
- Large EW tankhouse design evolved at the same time as permanent cathode technology in the 80's
  - Forty Eight (48) permanent cathode (XT and OT)
  - Seventeen (17) starter sheet
- Isa Process and Kidd Process are now supplied by one source Xstrata technologies (XT)
- Stripping machine suppliers include:
  - Outotec (Wenmec)
  - XT: MESCO and robotic

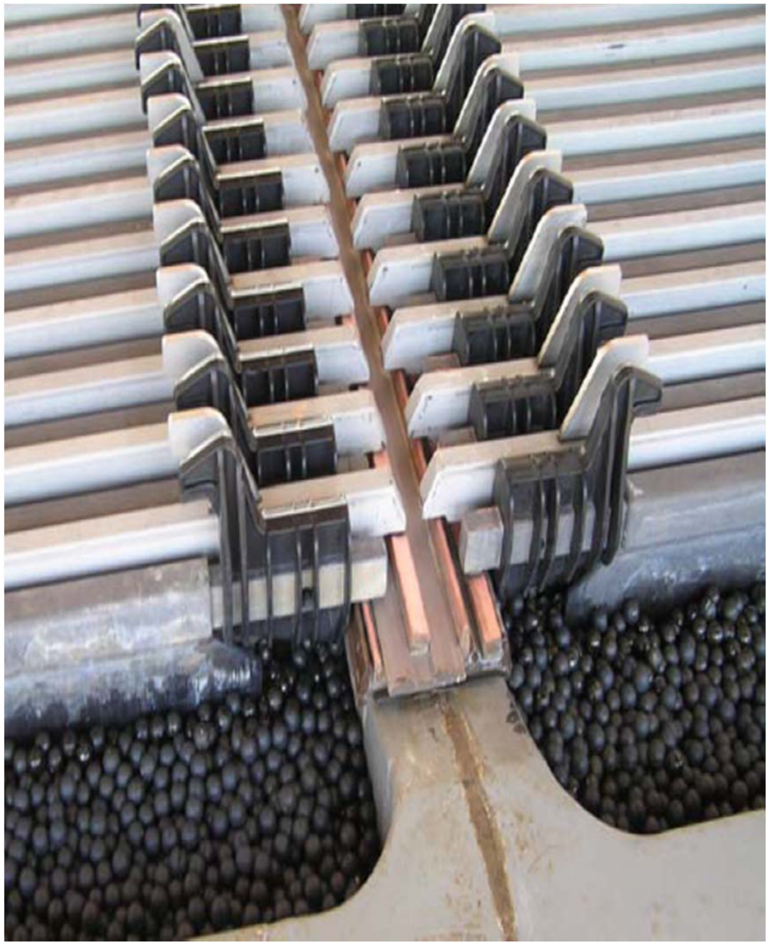
Freeport-McMoRan Copper & Gold

Cathode Plates

- Cathode design trends include:
  - Longer cathodes to minimize EW tankhouse footprint
    - Safford has 1.3 m long cathodes
  - Hooks on hanger bar as per Zinc EW for automated crane and rapid pick up
    - Outotec cathode design
    - Spence
  - Higher energy efficiency with designs that include more copper in/on hanger bar

FREEPORT-McMoRAN COPPER & GOLD

Cathode Plate Design



FREEPORT-MCMORAN COPPER & GOLD

Starter Sheet Technology

- EW plants that use a cathode starter sheet press include:
  - Cerro Verde, Miami, Chino and Tyrone
- Copper refineries have supplied copper starter sheets to nearby EW plants include:
  - SW USA:
    - El Paso for Chino, Sierrita and Tyrone
    - Miami for Tohono and Bagdad

FREEPORT-MCMORAN COPPER & GOLD

Starter Sheet Press – Chino

FREEPORT-MCMORAN COPPER & GOLD

Current Density

- According to the time of the survey Cerro Verde starter sheet EW plant in Peru at 400 A/m2
- It is reported today that Cerro Verde has operated at 450 A/m^2 in the past
- Other high current density plants include EW that uses air sparging
- African EW plants

Anodes

- Approximately 90% of the surveyed EW plants use anodes that are rolled lead calcium tin alloy with older plants using cast antimonial lead
- Anode life is:
  - Typically 6 years (design)
  - Some plants claim life of 10 years
  - High CD operations claim 3 to 4 years life
- Surveyed plants indicate cells are cleaned of lead sludge every 60 to 90 days but high CD plants clean every 30 to 40 days

FREEPORT-McMoRAN COPPER & GOLD

Alternative Anodes

- Alternative anodes
  - Approx 15% power savings
  - No cleaning of cells
  - Remove lead from EW system
- Titanium mesh with PM coating
- Being demonstrated in SW USA

Alternative Anodes

Alternative Anode Development

FREEPORT-MCMORAN COPPER & GOLD

Automatic Cranes

- First copper EW application of automatic cranes was El Abra in mid 90's
- These cranes give precise location of electrodes in the cells and can increase current and time efficiency
- Cranes use cone or laser method of cell location
- They are becoming an essential complement to hooded acid mist suppression technologies
- Suppliers in copper EW include Kunz, Femont and Outotec

Automated Cranes

Freeport-McMoRan Copper & Gold

Electrolytic Cells

- Over three quarters of surveyed EW plants use Polymer concrete (PC) cells
- Regions where polymer concrete is not used is at the older EW plants in Africa and USA
- New cell developments include:
  - Cells on floor level for low profile and cost tankhouse design
  - Longer and deeper cell length to minimize tankhouse footprint
  - Higher cell flows

Cells

FREEPORT-MCMORAN COPPER & GOLD

Air Sparging

- Air Sparging in cells
  - Higher current density operation
  - Improved cathode physical and chemical quality
  - Enables cells to potentially run at lower copper tenors and temperatures and still achieve quality
- This technology has been installed in all BHP Billiton EW plants and Codelco Gaby

Electrolyte Additives

- Reagents such as guar-type agent and cobalt sulfate are added to the electrolyte to enhance cathode quality
- From the survey, Guar dosage is 200 to 1000g/T cathode produced
- Higher current density operations such as CV typically use more Guar per tonne of production
- CV also uses a Collamat to monitor Guar online as per ER operations (glue)
- Some plants in North and South America are using a modified starch as a cathode smoothing agent
- Typical cobalt dosage from the survey is 100 to 200 ppm (in electrolyte) but this is higher in some African operations because by-product cobalt is entrained in electrolyte

Electrode Contact Systems

- Older designs include;
  - Simple triangular bar for asymmetric anode
    - Simple and can be rotated for extra life
    - Less copper
  - Dogbone bar for symmetrical anode
    - More copper but more expensive
- Latest designs include:
  - Double contact systems
  - Anode only
  - Cathode and anode (or double double: DD)

Double Contact

FREEPORT-MCMORAN COPPER & GOLD

Mist Suppression

- Nascent oxygen is formed at the anode face in the copper EW reaction and creates acid mist in the tankhouse
- Recent trends indicate the use of cell hoods for mist suppression
- First recent references were in Chile in mid 90's at Los Bronces
- Other methods of mist suppression include foams (FC 1100), plastic balls, plastic beads, forced flow ventilation, open tankhouse designs and anode brushes
- According to the 2006/07 survey, once again most EW plants use a combination of methods to suppress acid mist

Cell Top Hoods

Online Cell Voltage Monitoring

- Recent trend is to install online cell voltage monitoring (CVM)
  - Cell voltage and temperature
  - Wireless
- Originally developed for electrorefining tankhouses in 70's but not wireless
- Installed at Outotec tankhouses and CV
- MIPAC also has a system

Automated Online Cell Voltage and Temperature Monitoring

EW Development Summary

- Energy efficient alternative (non lead)anodes
- Air sparging
  - For higher current density operation
  - improved physical EW cathode quality
- More electrode handling automation
- Deeper and longer cells
  - Larger electrodes
  - Cells on ground level
  - More integrated design with cell
- Higher current density operation
- Cell hoods for acid mist suppression

FREEPORT-MCMORAN COPPER & GOLD

EW Development Summary

- Other developments not surveyed but in demonstration or pilot in Chile:
  - Cartridge electrode cell loading/spacing (Sele)
    - High current density
    - Improved physical cathode quality
    - No edge strips
  - Hecker AC modified DC current supply to EW
    - Cathode smoothing