Technical Leadership in Mining & Energy

THE DEVELOPMENT OF PERMANENT COPPER CATHODES
Development of Permanent Copper Cathodes

- Copper production value chain
- Critical component in the production cycle
- Copper Cathode components and development
- Advantages of better conductivity
## Copper Production Value Chain

### Costs (Approximate total steady state operating costs)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Opencast (oxide)</th>
<th>Capital Investment &amp; Development</th>
<th>Orebody Development</th>
<th>Milling &amp; Concentration</th>
<th>Metal Refining</th>
<th>Sales &amp; Market</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral Rights</td>
<td>9%</td>
<td>19%</td>
<td>43%</td>
<td>9%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U/G (sulphide)</td>
<td>2-3%</td>
<td>58%</td>
<td>15%</td>
<td>19%</td>
<td></td>
<td>6%</td>
<td></td>
</tr>
</tbody>
</table>

Note: Copper Production Value Chain takes into account various stages of production, from mineral rights to distribution. The table above outlines approximate total steady state operating costs for each stage.
Typical Copper Leaching/Electro-winning Process
**Tank House Performance**

- **Tank Temp** approx. 40-50°C
- **Voltage required** 1.8-2.2V
- **Current across a cell** is 600A
- **Anode Spacing** is +/- 95mm apart
- **Cathode size** is approx. 1m²

Each Cathode produces approx. 50kg per side per 7 day cycle. 
I.e. 100kg per 7 days or 5.2 tons/yr

At $6000/t of Cu, each cathode generates $32000 per annum

A cathode life expectancy is 10-15 years, generating $220 000 - $320 000.
Evolution of the Permanent Copper Cathode

- Early copper plating was done using Starter Copper Sheets

- In late 1970’s, Mt. Isa developed the permanent 316L Stainless steel cathode
  - 3.25mm 316L Stainless Steel sheet welded onto a 304L Header bar.
  - Header bar electroplated with Cu 2.5mm thick.
  - 3 sides of blade covered with insulating edge strips
Evolution of the Permanent Copper Cathode

Characteristic requirements of a permanent cathode

- Conductivity
- Straightness
- Rigid/Robust
- Smoothness
Evolution of the Permanent Copper Cathode

- Solid copper header bar bolted to the blade - improve conductivity
- Solid copper header bar with stainless steel strip on the bottom - improve rigidity
- Solid copper header bar with explosion welded stainless steel lugs to attach the blade – improve conductivity
- Solid copper header bar sleeved in stainless steel tube - improve blade attachment - reduce copper dissolution
- Explosion bonded copper bar in a stainless steel tube - improve conductivity - improve rigidity
Evolution of the Permanent Copper Cathode

- Co-Extruded copper bar and stainless steel tube  - improve conductivity
  - improve rigidity

- Styria Bi-Metal Header bar, which is a solid copper header bar metallurgically bonded to the stainless steel tube which encases it.
  - Blade can be either crank welded or butt welded.
  - The stainless steel tube on the ends is machined away for full copper conductivity onto the copper busbar.
Evolution of the Permanent Copper Cathode

First permanent cathode header bar

Solid copper header bar with explosion bonded tabs for blade connection

Solid copper rod inside a stainless steel casing onto which the blade is butt or crank welded

Styria Stainless Steel Fabrication

www.cbm-tec.com
What constitutes a good Permanent Cathode?

- Conductivity
- Straightness
- Rigid/Robust
- Smoothness
What constitutes a good Permanent Cathode?

- **Conductivity**
- Reduce power consumption
- Reduce heat build-up
- Improve uniformity of copper deposit
What constitutes a good Permanent Cathode?

- **Straightness**
- Seamless mechanical handling from cells to stripping machine
- Ease of stripping
- Uniform electric field in copper solution
- Even copper deposit on cathode
- Limits electrical shorting
What constitutes a good Permanent Cathode?

- Rigid/Robust
What constitutes a good Permanent Cathode?

- Smoothness
- 316L cold rolled stainless steel (2B Mill Finish)
- Ease of stripping
- Limits aggressive copper removal
- Productivity
Components of a Permanent Cathode

- Header bar
- Blade
- Edge strips
Components of a Permanent Cathode

- **Blade**
  - Is used as the blank on which the electro-won copper is deposited
  - 316L Stainless steel with “cloudy mirror” finish to assist stripping
  - Durable to withstand aggressive stripping
  - Straight
  - Flat (double distressed to remove roll tension)
Components of a Permanent Cathode

- Blade
Components of a Permanent Cathode

Edge strips

- Ensures cathode edges are free of copper to assist in copper stripping
- Must be a sealed insulator to inhibit electro-currents
- Must be resistant to acid electrolyte
- Must be robust to withstand flexing and potential manual copper stripping
Components of a Permanent Cathode

Header bar

- Is the support for the blade hanging in the electrolyte
  - High conductivity due to the high ampere demand on the cathode
  - Robust to withstand plated mass of 150kg
  - Should be corrosion resistant as it is subject to acid mist
Header Bar Configurations & Conductivity Comparison

- Header bar
- Stainless Steel vs Copper header bars
- Bolted vs Welded
- Cranked vs Straight, butt welded
- Contact point of header bar on the busbar
- Styria comparative tests on different busbars and configurations

Megger Meter DLRO 600
Conductivity

600Amps

Ω 1
Ω 2
Ω 3
Etc.

Styria Stainless Steel Fabrication

www.cbm-tec.com
Conductivity

Components

- Copper solid bar (1300mm)  49mΩ
- Stainless steel hollow tube (1300mm)  4750mΩ
- Stainless Steel Blade (1100mm)  778mΩ

Configurations

- Blade only
- Blade and stainless steel tube clamped
- Copper Bar clamped to the blade
- Imported co-extruded bar/stainless steel tube welded onto the cathode blade
- Styria Cathode which is a metallurgically bonded copper/stainless steel header bar welded onto the cathode
Conductivity

![Conductivity Graph]

**Number positions**

- Blade Only
- Blade and stainless steel tube clamped to blade
- Copper bar clamped to blade
- Metallurgically bonded bar welded to blade
- Co-Extruded bar welded to blade

**Milli-Ohms**

1  2  3  4  5  6  7  8  9
Energy Savings due to Good Cathode Performance

- Tank house Current efficiency = \( \frac{\text{Actual copper produced}}{\text{Theoretical copper produced}} \)
- Typical performance internationally is 85%-90%
- Each 1% improvement in current efficiency results in 1.5% improvement in copper production
- Current efficiency is affected by losses within the plant and effective use of the available power:
  - Cathode resistance
  - Electrolyte Chemistry
  - Electrical Contacts
  - Electrical Shorts
- Power losses in poor conductivity or poor contacts are converted into heat and energy loss, or can cause potential damage to equipment.
Energy Savings due to Good Cathode Performance

- Cathode energy power saving amounts to 11%-13% for the fully welded blade onto integrated encapsulated copper header bar.
- The locally produced metallurgically bonded Styria cathode performs as well as imported cathodes.
- Improved conductivity can reduce production costs by approximately $5-6/ton of copper.
- For a plant producing 50 000tpa of copper, electrical savings could amount to $300 000 per annum.
- Savings are considerably more for processing plants operating on Diesel generated power.
Summary of Outcomes

- The outer stainless steel tube:
  - improves the robustness and therefore the handling of the cathode
  - prevents dissolution of the copper in the header bar
  - allows for the blade to be comprehensively welded to the hanger bar
- **Electricity savings of a good performing cathode can be as $5-6 per ton of copper produced**
- For plants where electric power is a limiting factor, improved conductivity allows for a consequential improvement in copper production
- **Styria Stainless Steel offers a competitive SADC produced Cathode allowing clients to enjoy the currency exchange benefit, short pipeline delivery and comparative best industry performance.**
Acknowledgements

- The development of a “lower resistance” permanent Cathode – Webb, Weston (Isa Process Technology)
- Developments in permanent stainless Steel cathodes within the copper industry – Eastwood, Whebell (Extrata Technology)
- Copper electrowinning: Theoretical and practical design – Beukes and Badenhorst (TWP Matomo Process Plant)
- Copper Electrowinning: 2013 World Tankhouse Operating Data – TG Robinson et al.
Thank you