Cell Voltage Noise Removal
and Cell Voltage (or Resistance)
Slope Calculation

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GENISIM
Plan of the Presentation

- Introduction
- Noise Filtration and Slope Calculation
  - linear fit
  - parabolic fit
- Conclusions
Introduction

Figure 2: Typical applications of pseudo-resistance for cell control.
Introduction

Calculation of the cell pseudo-resistance ($R$)
Introduction

Cell Voltage vs. Time

- w/o Amp. Fluctuation
- w/ Amp. Fluctuation
Introduction

Cell Pseudo-Resistance vs. Time

- w/o Amp. Fluctuation: BEMF = 1.770
- w/ Amp. Fluctuation: BEMF = 1.65
Introduction

Figure 3: Typical pseudo-resistance versus alumina concentration relationship at constant anode cathode distance.
**Introduction**

**Pareto Plot of Transformed Estimates**
Absolute effect sizes from high to low, and how they add up.

<table>
<thead>
<tr>
<th>Term</th>
<th>Orthog Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>C*al</td>
<td>-2.2569930</td>
</tr>
<tr>
<td>% Alumina</td>
<td>-1.1805344</td>
</tr>
<tr>
<td>(C<em>al)</em>(% Alumina)</td>
<td>-1.1782484</td>
</tr>
<tr>
<td>Noise</td>
<td>-1.0744226</td>
</tr>
<tr>
<td>(Noise)*(Anode current Balance)</td>
<td>-0.7800229</td>
</tr>
<tr>
<td>Cathode Overvoltage</td>
<td>0.7618233</td>
</tr>
<tr>
<td>Cathode voltage Drop</td>
<td>-0.7253440</td>
</tr>
<tr>
<td>AnodeCurrent Balance</td>
<td>-0.7247976</td>
</tr>
<tr>
<td>(Cathode Overvoltage)*(cathode voltage drop)</td>
<td>-0.2772371</td>
</tr>
</tbody>
</table>

![Graph showing High %CE and Low %CE with High C*Al and Low Alumina opposite Low C*Al and High Alumina.](image)

Gary P. Tarcy
Introduction

Small initial overfeeding with no alumina control

Negative CE vs. %Al₂O₃ Slope means unstable system
Introduction

Typical underfeed/overfeed strategy characteristics.
Introduction

Figure 3: Typical noise signals from stable and unstable cells

Voltage (20 mV increments)

ANODE

METAL

STABLE

Time (s)
Noise Filtration and Slope Calculation
Noise Filtration and Slope Calculation

First algorithm tested, linear fit:

- A cell voltage free of any amperage fluctuation noise is recomputed from the cell “pseudo-resistance” using the nominal amperage.

- The cell voltage computed this way every 6 seconds is then averaged every 2 minutes.

- The best straight line fitting the last 10 “2 minutes averaged cell voltage” is computed.

- Finally, the slope of that straight line is use as estimate of the cell voltage slope at that time.
Noise Filtration and Slope Calculation
Noise Filtration and Slope Calculation

Voltage noise filtration

Cell voltage (volts)

Time (minutes)

20 30 40 50 60 70 80 90 100

Noise Filtration and Slope Calculation
Noise Filtration and Slope Calculation

Voltage noise filtration

Cell voltage (volts)

Time (minutes)
Noise Filtration and Slope Calculation
Noise Filtration and Slope Calculation

Linear curve fitting vs. quadratic curve fitting, which gives the most accurate slope calculation?
Noise Filtration and Slope Calculation

First algorithm tested, quadratic fit:

- A cell voltage free of any amperage fluctuation noise is recomputed from the cell “pseudo-resistance” using the nominal amperage.

- The cell voltage computed this way every 6 seconds is then averaged every 2 minutes.

- The best parabolic curve fitting the last 10 “2 minutes averaged cell voltage” is computed.

- Finally, the slope of that parabolic curve at time 0 (linear term coefficient) is used as an estimate of the cell voltage.
Noise Filtration and Slope Calculation

Voltage noise filtration

Cell voltage (volts)

Time (minutes)
Noise Filtration and Slope Calculation

Voltage noise filtration

Time (minutes)

Cell Voltage (Vols)
Noise Filtration and Slope Calculation

![Voltage noise filtration graph](image)

- **Y-axis**: Cell voltage (volts)
- **X-axis**: Time (minutes)

The graph shows the decrease in cell voltage over time, indicating the noise filtration process and the calculation of the slope.
Noise Filtration and Slope Calculation

Voltage noise filtration

Cell voltage (volts) vs. Time (minutes)
Noise Filtration and Slope Calculation

Calculated voltage slope

- Time (minutes)
- Voltage slope (volt/min)
Conclusions

- Numerical algorithms that perform cell voltage noise removal and cell voltage (or resistance) slope calculation have been compared.

- High frequency voltage noise can be successfully removed using quite simple averaging and curve fitting techniques.

- A more complex and more CPU demanding parabolic curve fitting scheme produced a noisier and less accurate cell voltage slope estimation than a simpler straight line fitting scheme.

- Next step would be to test the cell voltage noise removal algorithm "on-line" as part of a continuous tracking alumina feeding control algorithm in a dynamic cell simulator.