Simulation of the Dynamic Response of Aluminum Reduction Cells

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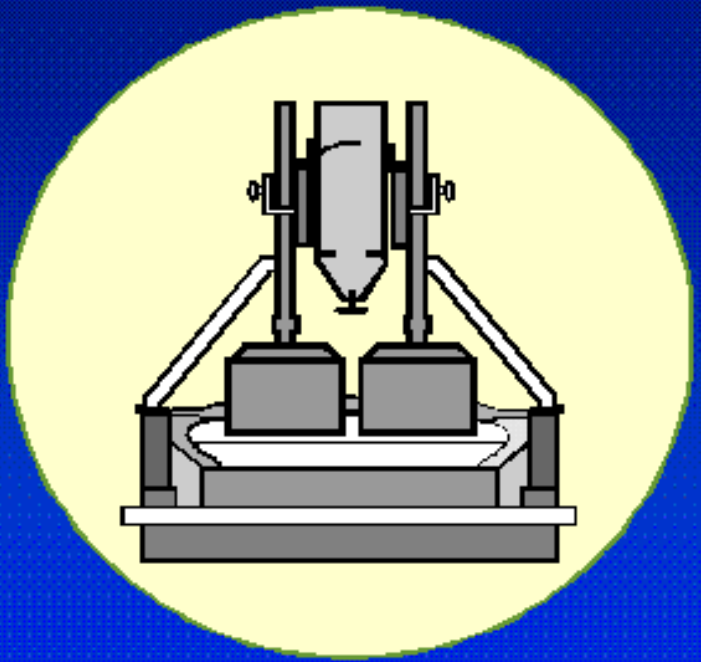
Overview of the Dynamic Model

Process Model



Control Model

Constitutive Equations

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Steady State Solution

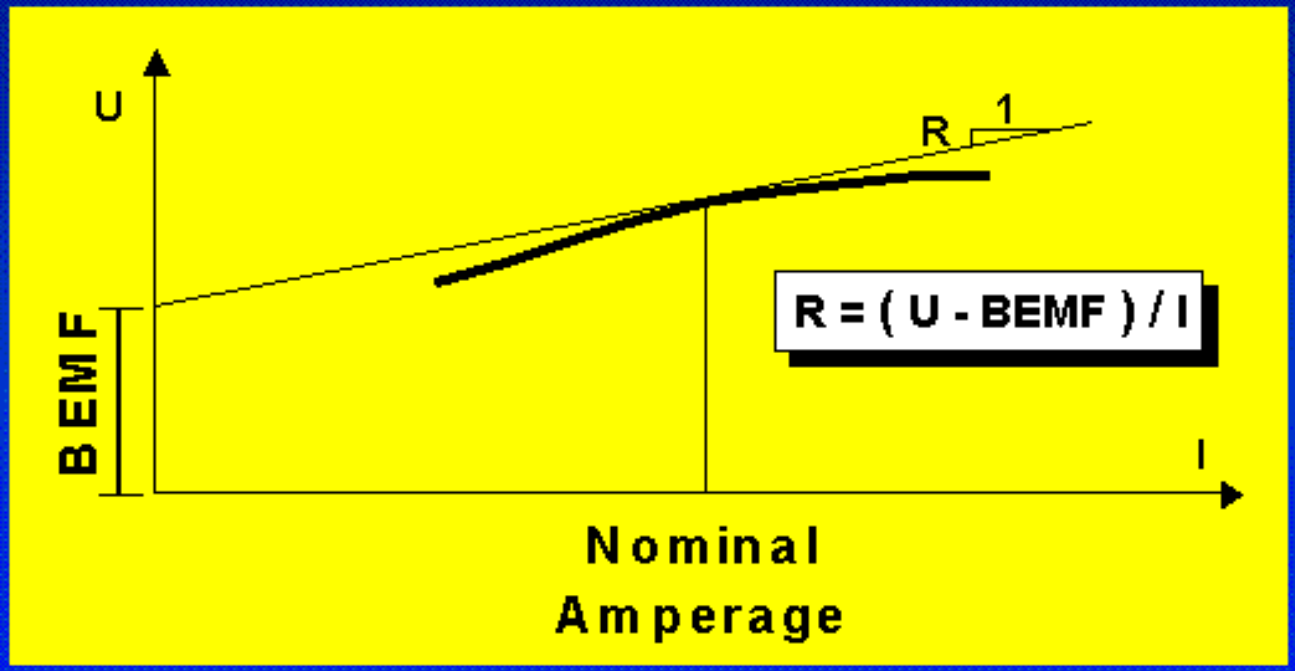
- Governing Equation
  - Internal Heat = Heat Loss
- 18 Target Variables
  - ACD, Amperage, Temperature, Concentrations, ...
- Monte Carlo Simulation
  - Probability distribution of input variables

Cell Amperage Submodel

- Amperage Fluctuation
  - Maximum rectifier capacity
  - Total line voltage
  - Target cell amperage
  - Anode effects
- Amperage Curtailment

ACD Regulation

- Control the cell pseudo-resistance (R) rather than cell voltage



Factors Affecting BEMF

- **Cell Voltage:**

$$U_{cell} = U_{bath} + U_{elec} + U_{ext} + U_{anode} + U_{cathode}$$

$$U_{bath} = f\left(R_{bath}, R_{bubble} \right)$$

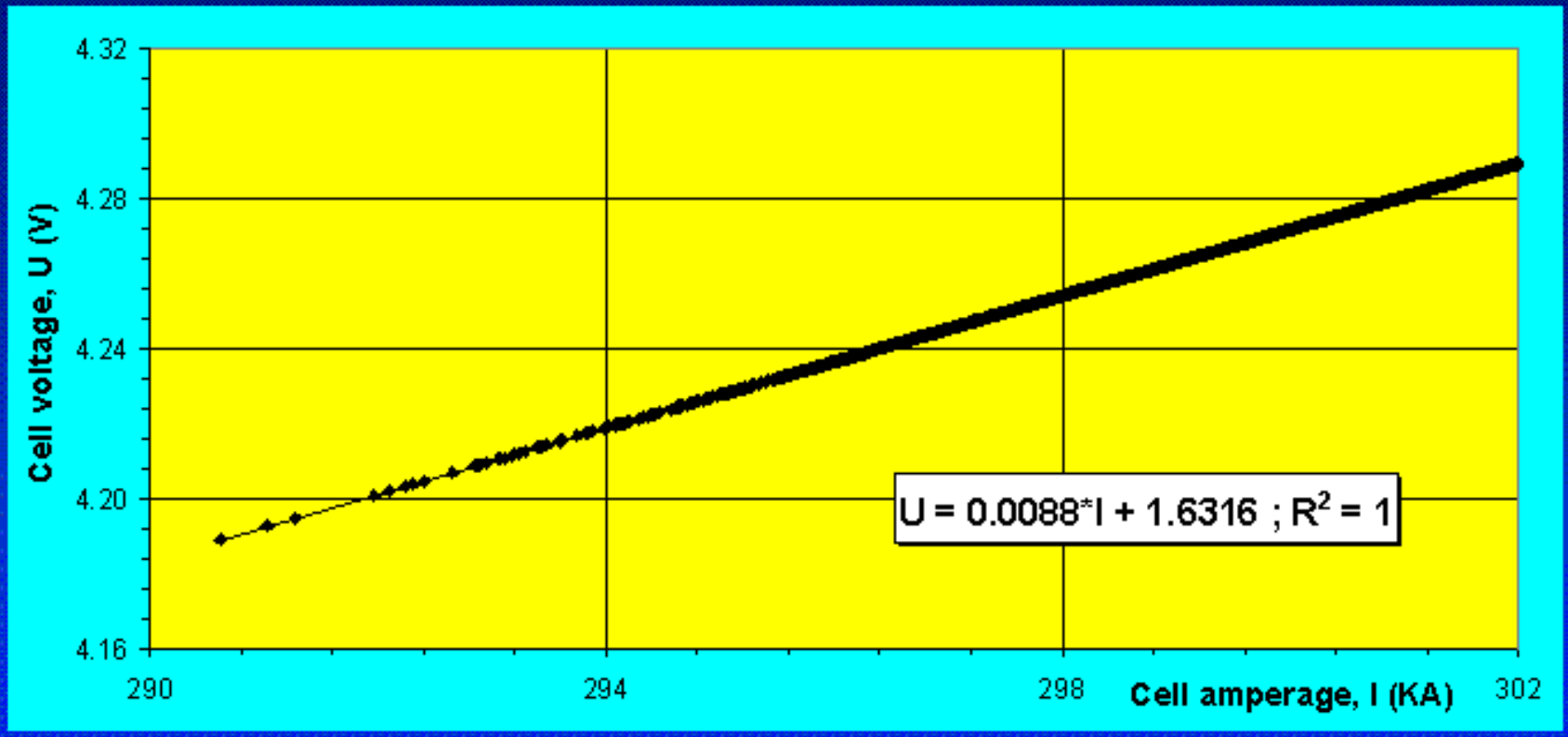
$$U_{elec} = g\left(E^{rev}, \eta_{cc}, \eta_{aa}, \eta_{ac} \right)$$

Case I : 300 kA PBF Cell

- Calculate BEMF under two conditions:
  - Constant ACD & Cell Temperature
  - Constant ACD
- Evaluate the efficiency of the BEMF as a filter for the amperage fluctuation.

Cell Voltage vs. Amperage

(Constant ACD and Temperature)



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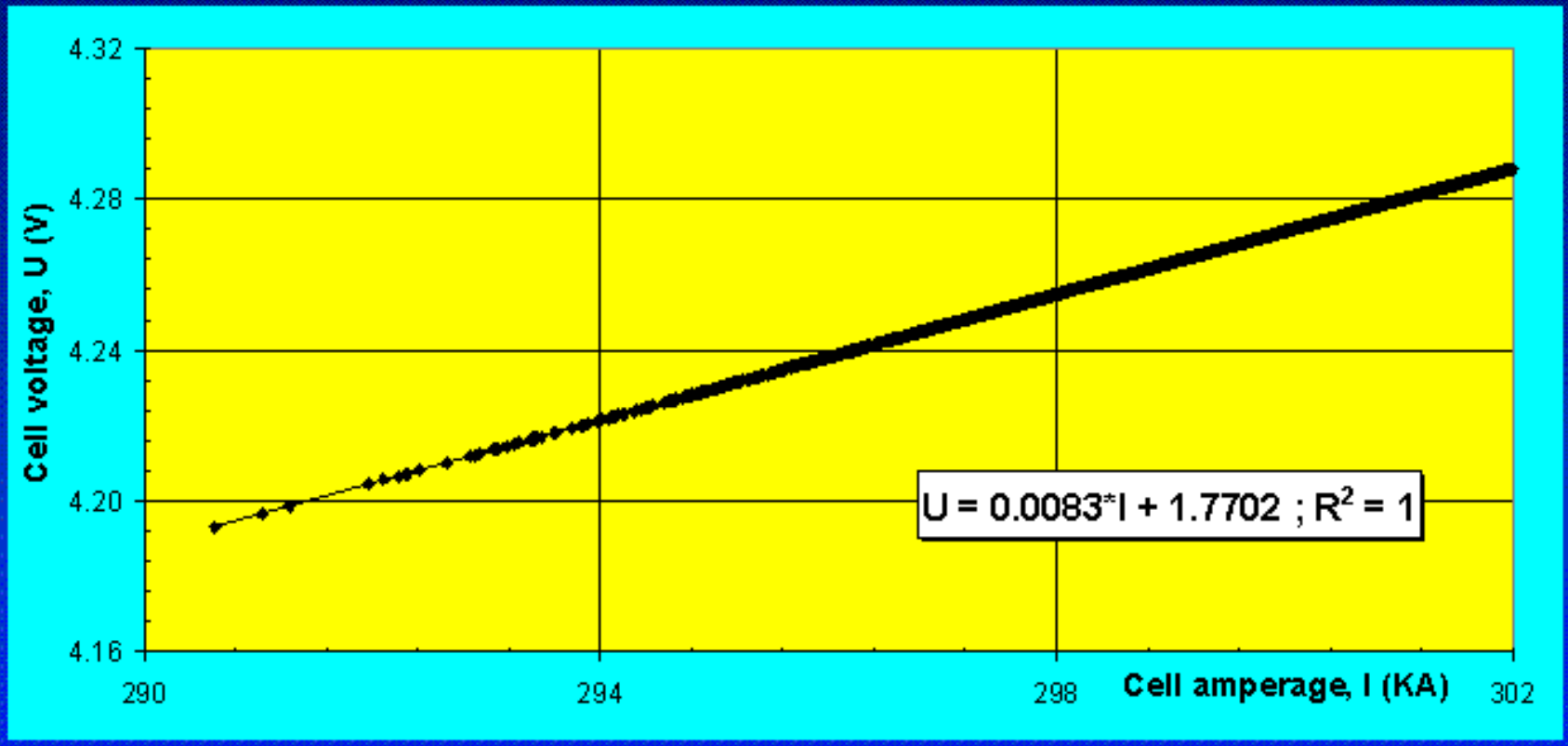
Cell Voltage vs. Amperage

(Constant ACD)



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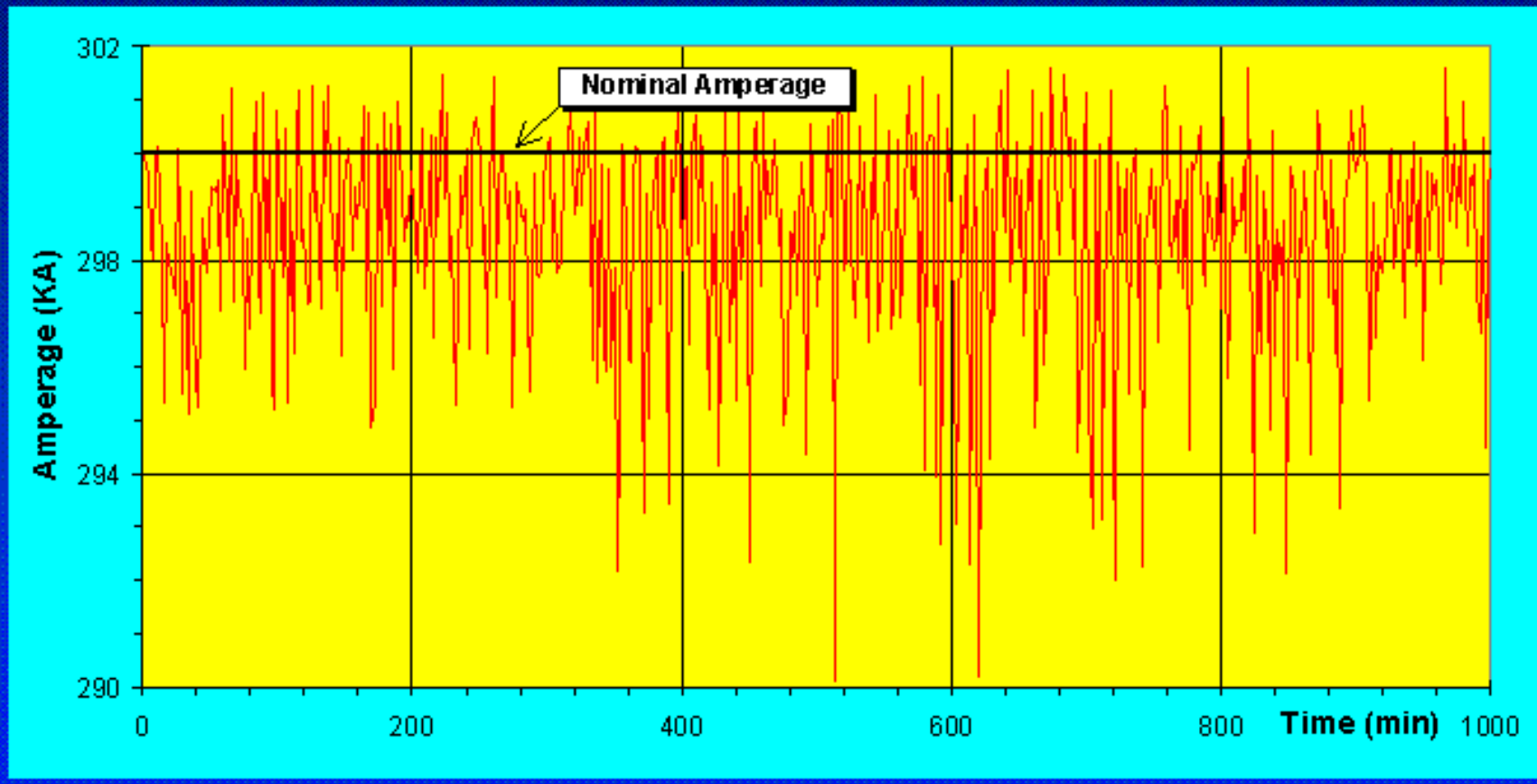
Cell Amperage vs. Time

(BEMF = 1.65)



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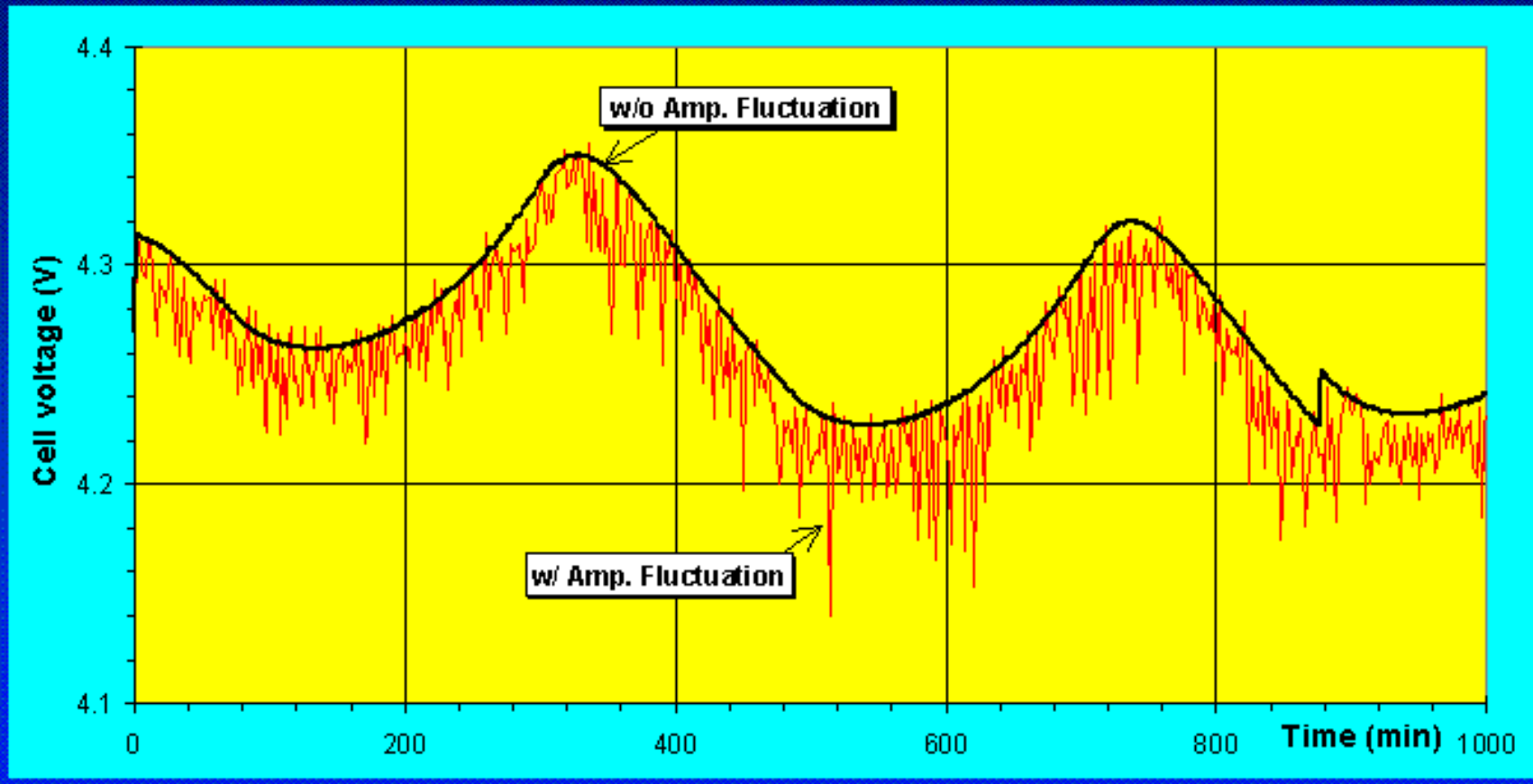
Cell Voltage vs. Time

(BEMF = 1.65)



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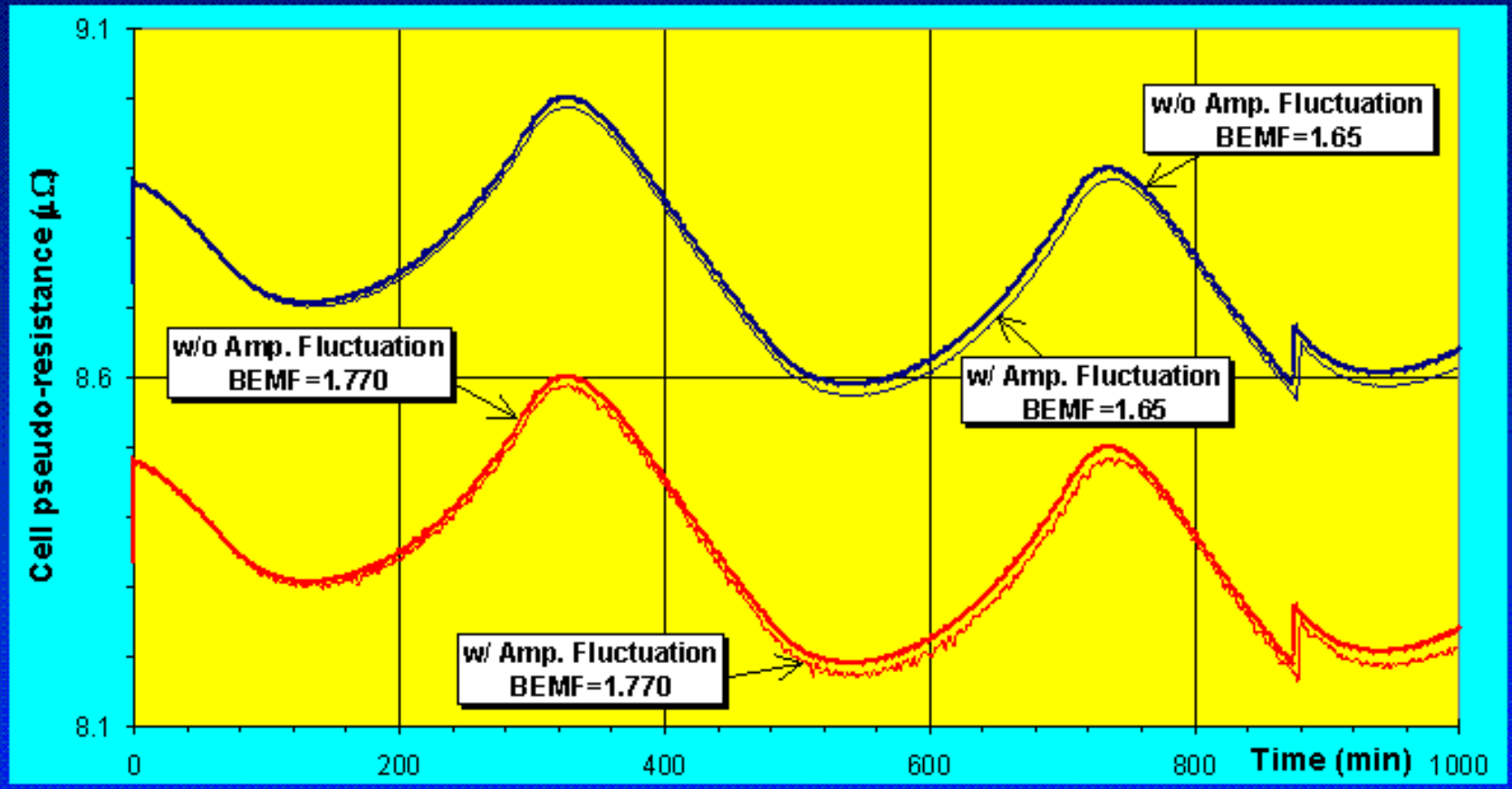
Cell Pseudo-Resistance vs. Time



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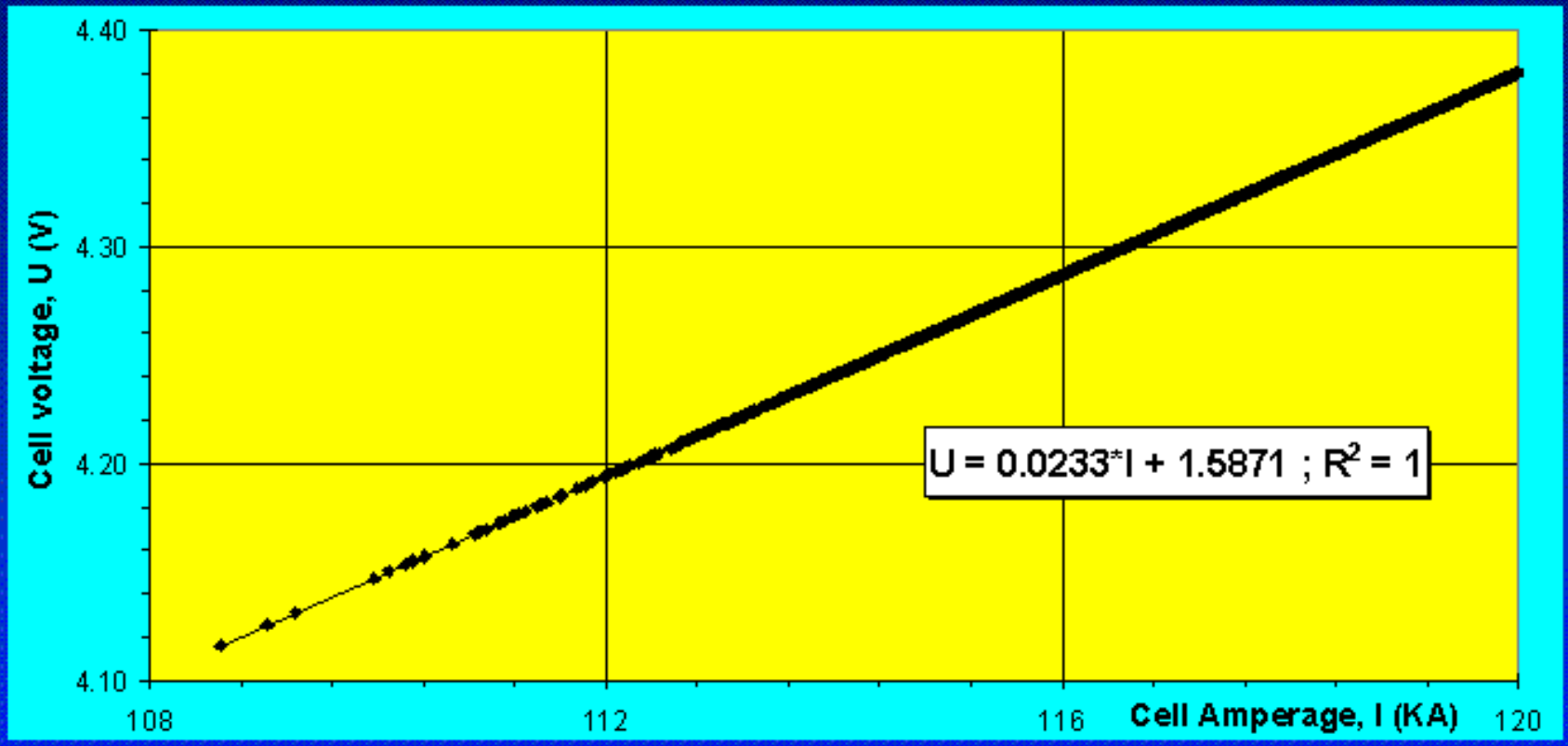
Case II: 120 kA Söderberg Cell

- Evaluate the efficiency of the BEMF as a filter for the amperage fluctuation.

Cell Voltage vs. Amperage

(Constant ACD and Temperature)



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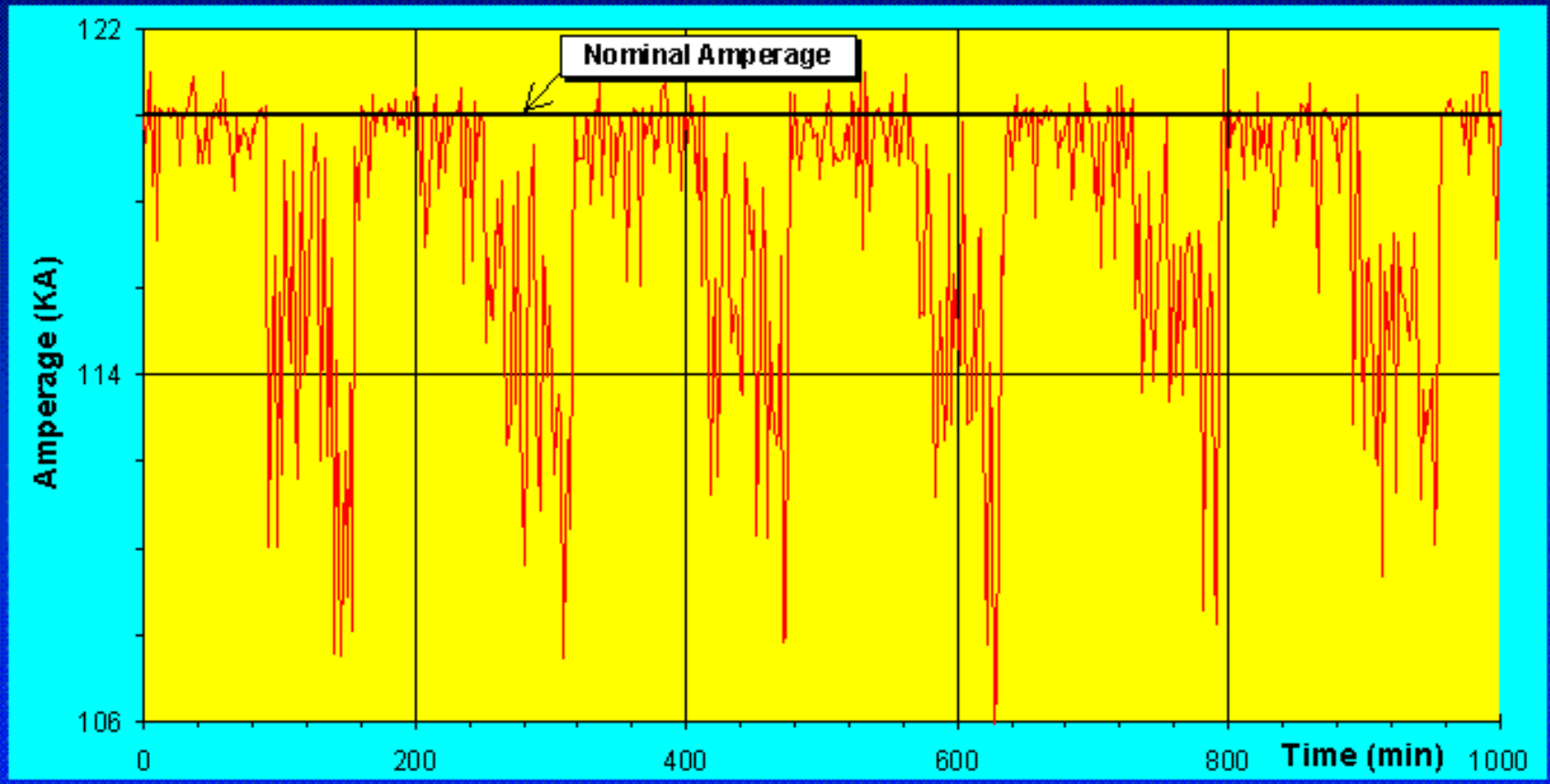
Cell Amperage vs. Time

(BEMF = 1.65)



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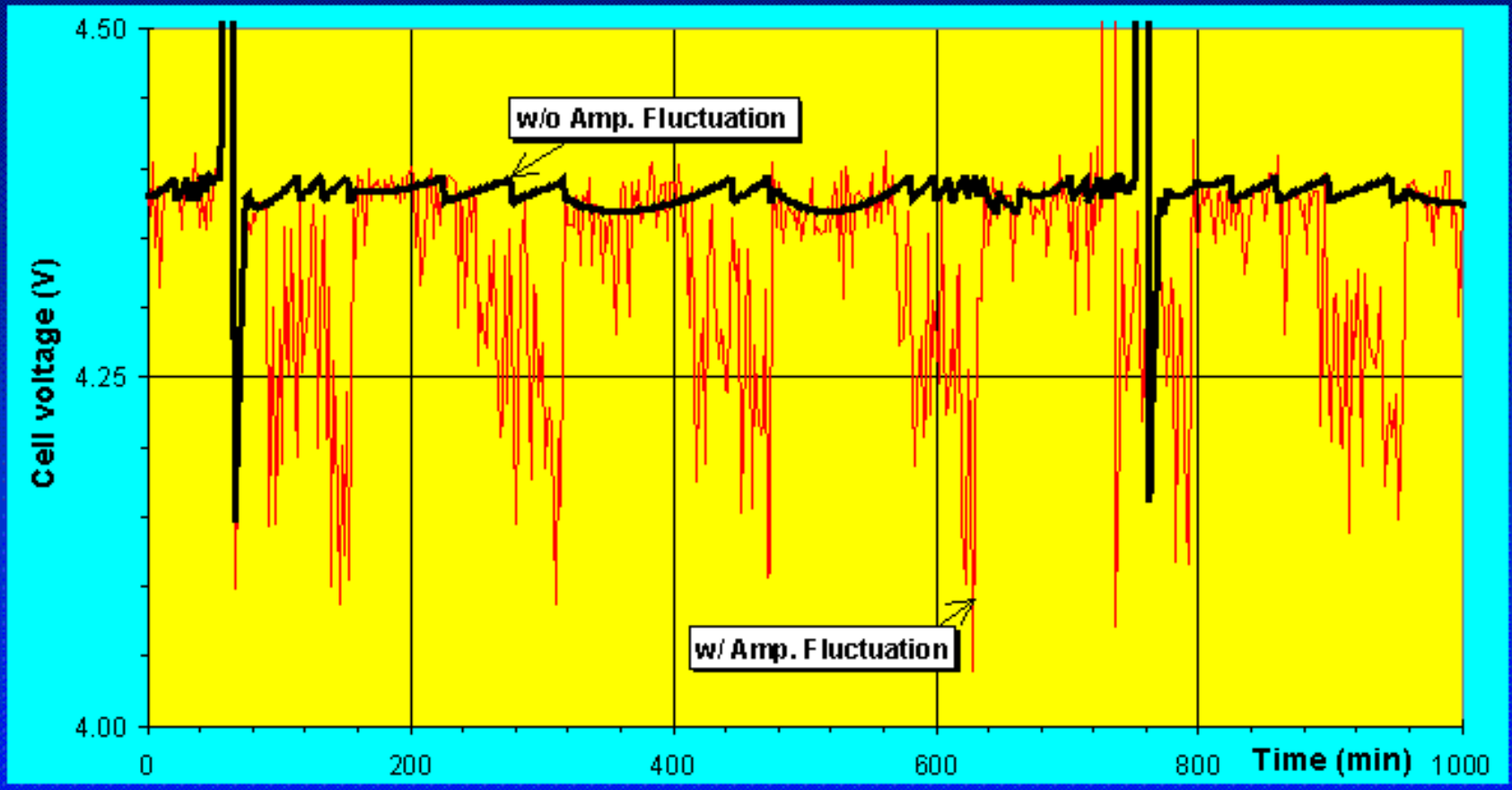
Cell Voltage vs. Time

(BEMF = 1.65)



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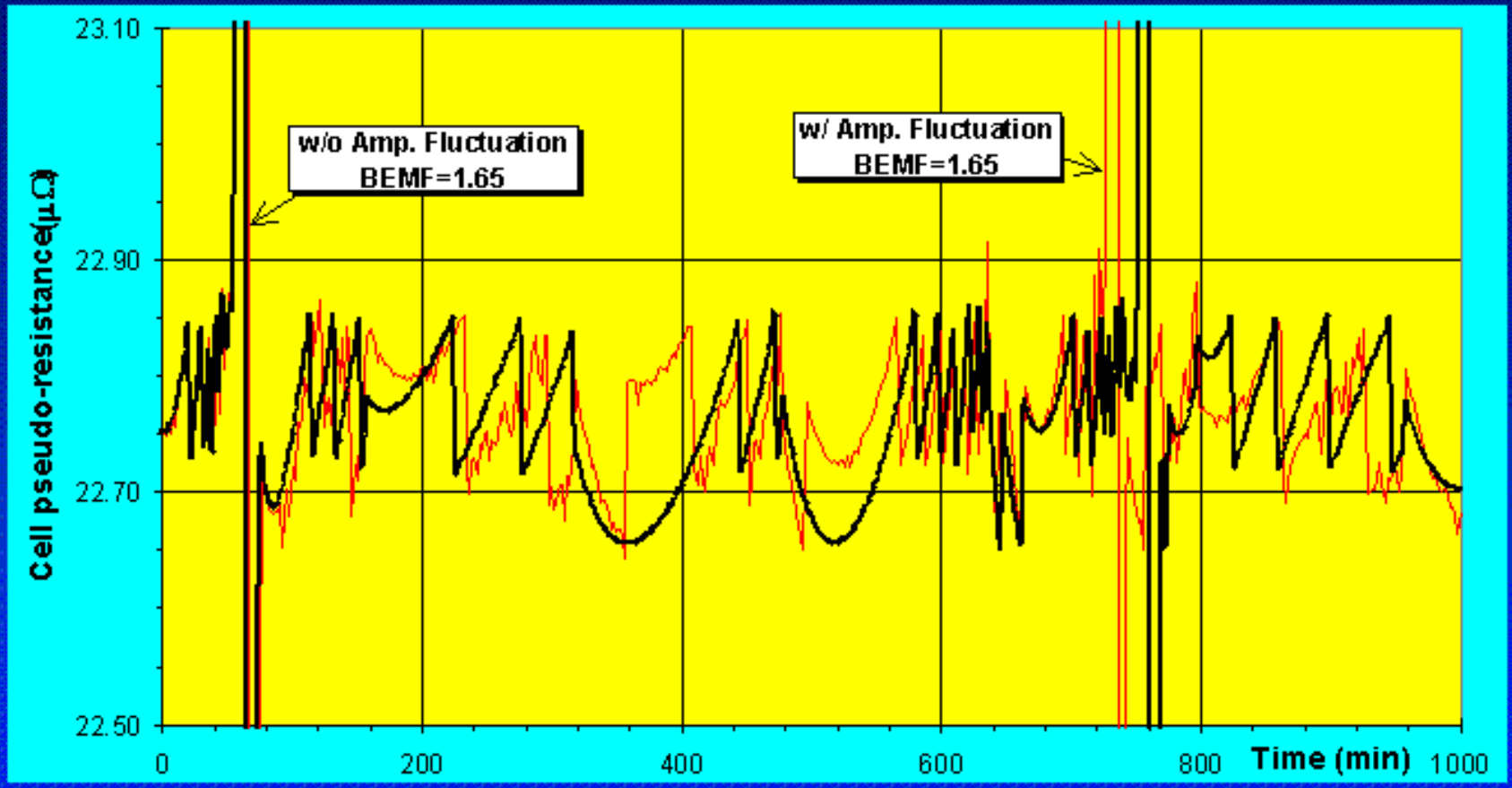
Cell Pseudo-Resistance vs. Time



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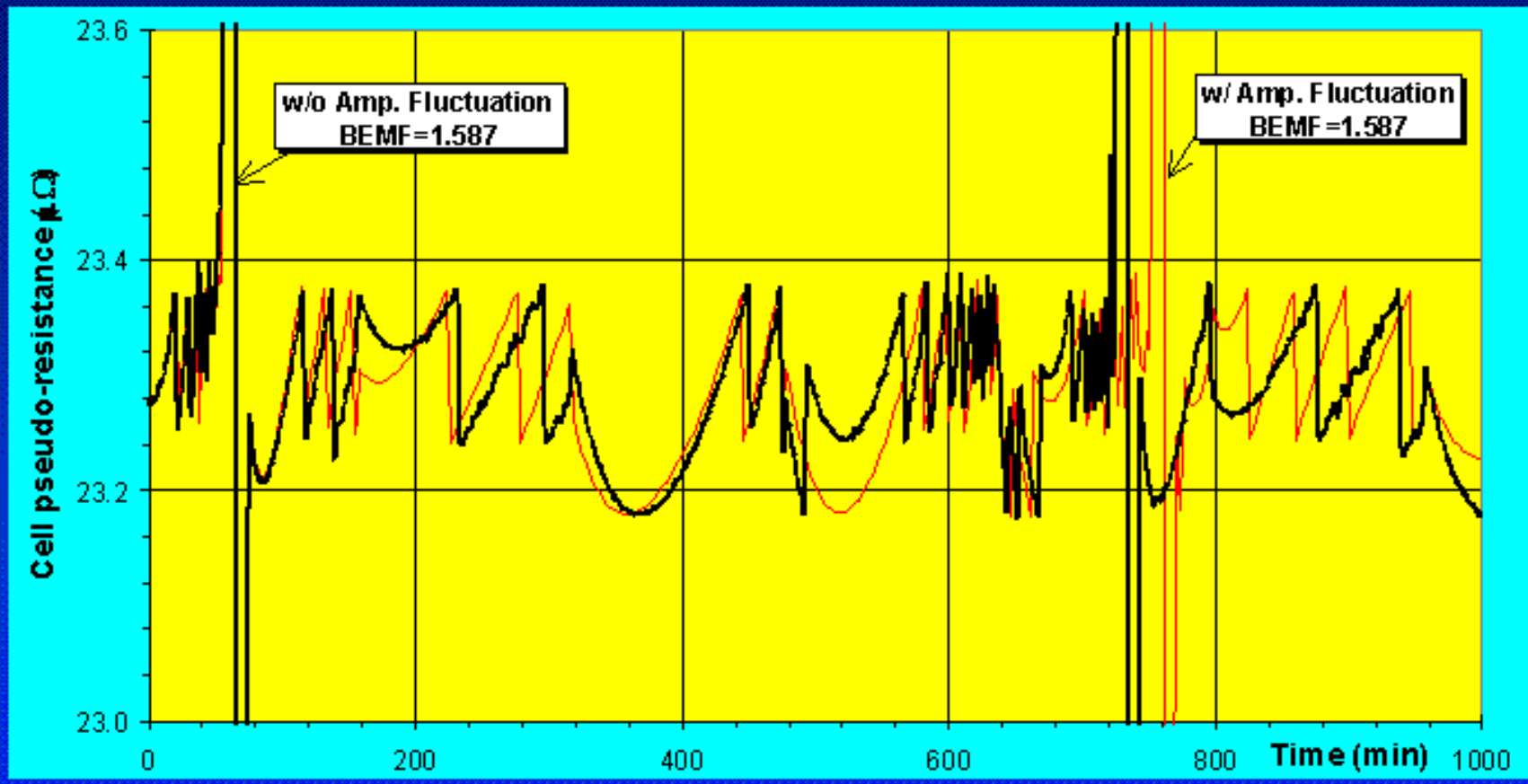
Cell Pseudo-Resistance vs. Time



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Conclusions

- Amperage fluctuation due to Anode Effects can be efficiently filtered using the cell pseudo-resistance.
- PBF cells are more forgiving than side break cells when the wrong BEMF value is used.
- The procedure for calculating the BEMF is important.