Computation of Aluminum Reduction Cell Energy Balance Using ANSYS® Finite Element Models

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Plan of the Presentation

Brief historical review

Advantages of using 3D finite element models based on commercial software

Inspiration source of the presented demonstration models geometry

The 3D half anode model

The 3D cathode slice model

The 3D full cell slice model

The 3D cathode corner/quarter model

The 3D anode panel corner/quarter model

The 3D full cell corner/quarter model

The 2D+ full cell model
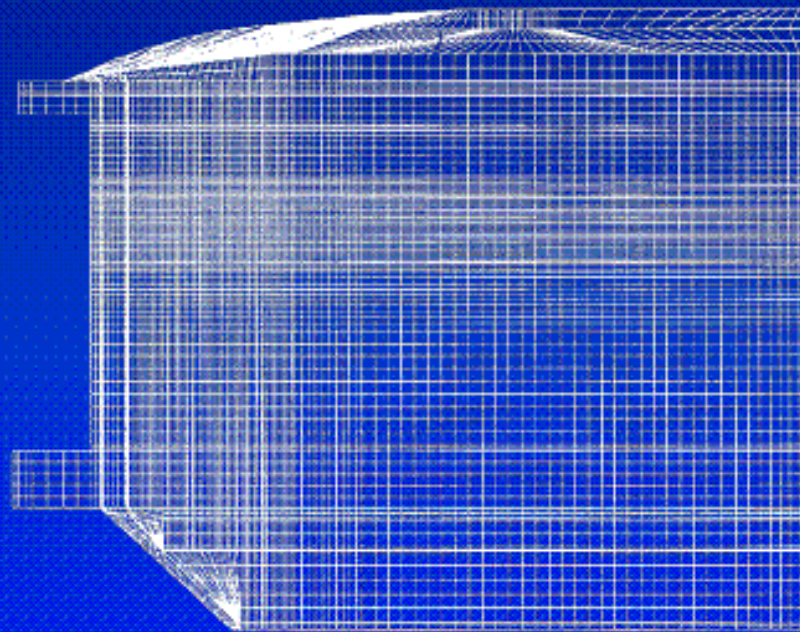
Models comparison summary table
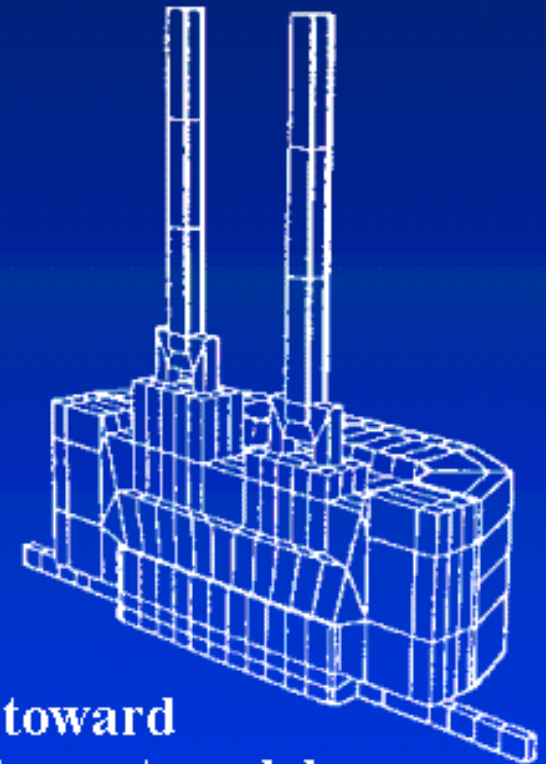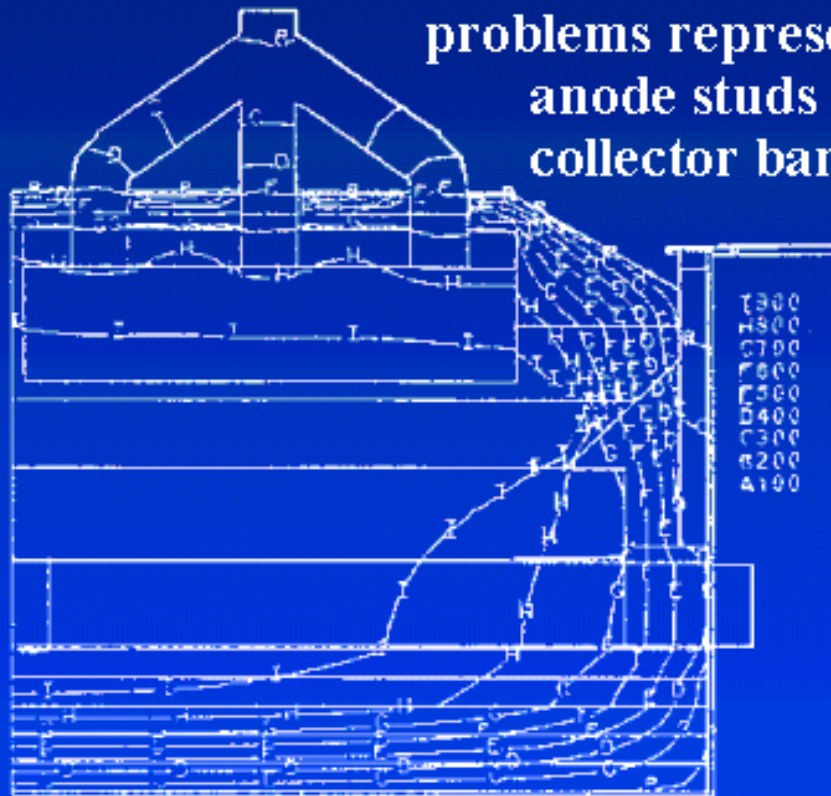
Conclusions

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Brief Historical Review

- **In-house 2D models:**
  - 2D thermal model with assumed source terms

Brief Historical Review

- **2D thermal-electric that have problems representing the anode studs and cathode collector bar**

- **Migration toward 3D finite element models based on commercial software**

Advantages of Using 3D Finite Element Models Based on Commercial Software

- Cell lining design have complex geometry that can be easily handled by the finite element numerical method

- Cell lining design cannot be reduced to a pure 2D model representation

- The scope of developing an in-house 3D finite element software exceeds the limited resources of in-house code developers

- Finite element softwares on the market are robust, user-friendly and do offer all the required thermo-electric capabilities
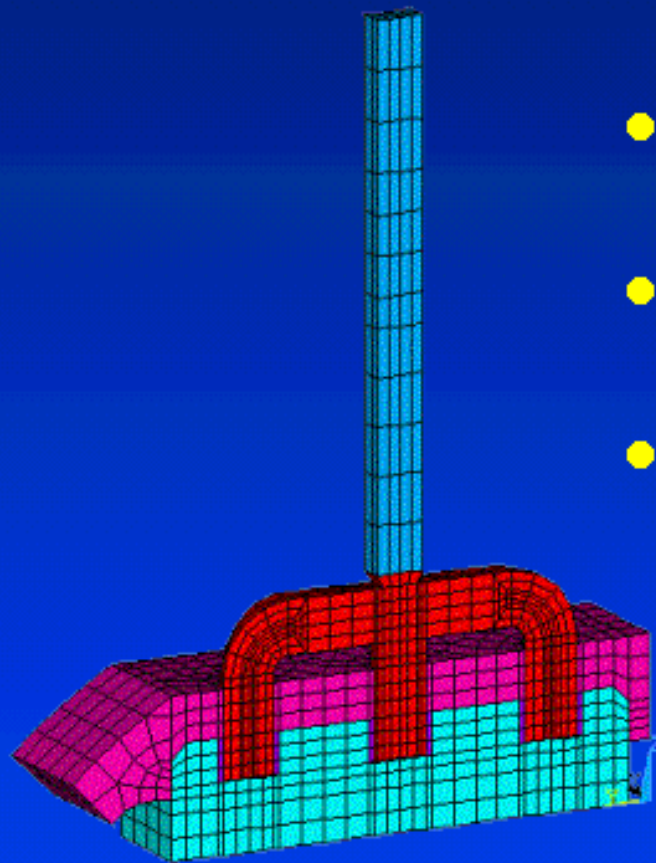
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The 3D Half Anode Model

- Accurate anode studs and rod voltage drop as well as heat loss representation

- Accurate cast iron to carbon contact resistance representation

- Fairly accurate total anode panel heat loss representation

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The 3D Cathode Slice Model
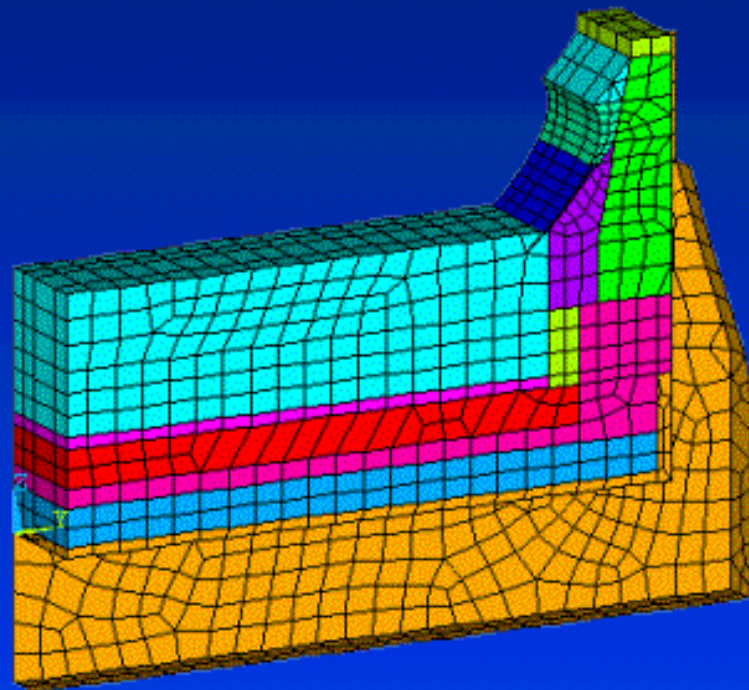
- Accurate collector bar voltage drop and heat loss representation

- Accurate shell and cradle heat loss representation

- Accurate cast iron to carbon contact resistance representation

- Fairly accurate total cathode heat loss representation (rely on a good estimation of the end wall heat loss)

The 3D Full Cell Slice Model
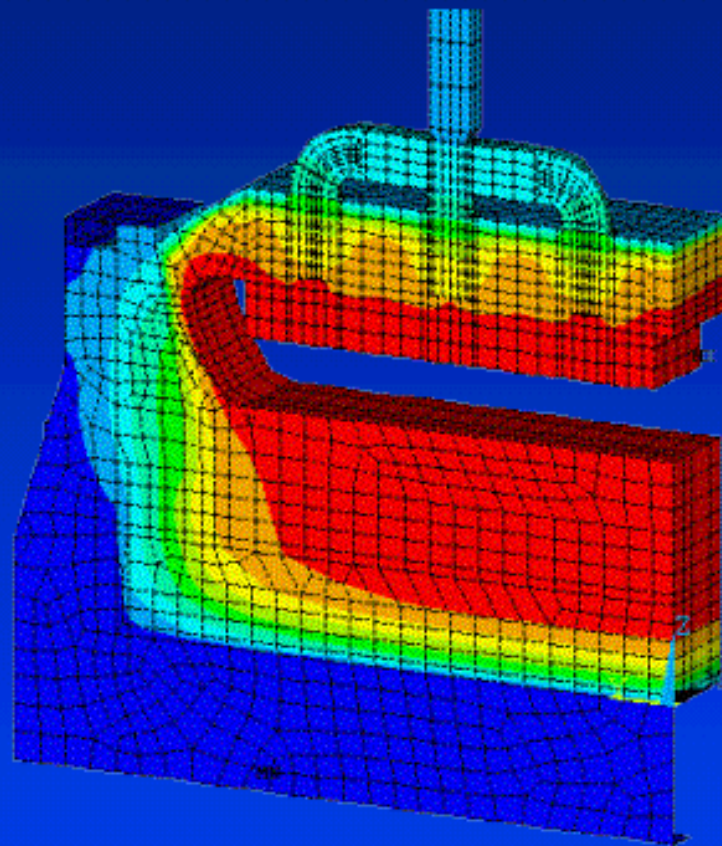
- Accurate side channel crust and top ledge interface representation

- Converged on steady-state conditions without user intervention

- Fairly accurate total cell heat loss representation (rely on a good estimation of the cathode end wall heat loss)

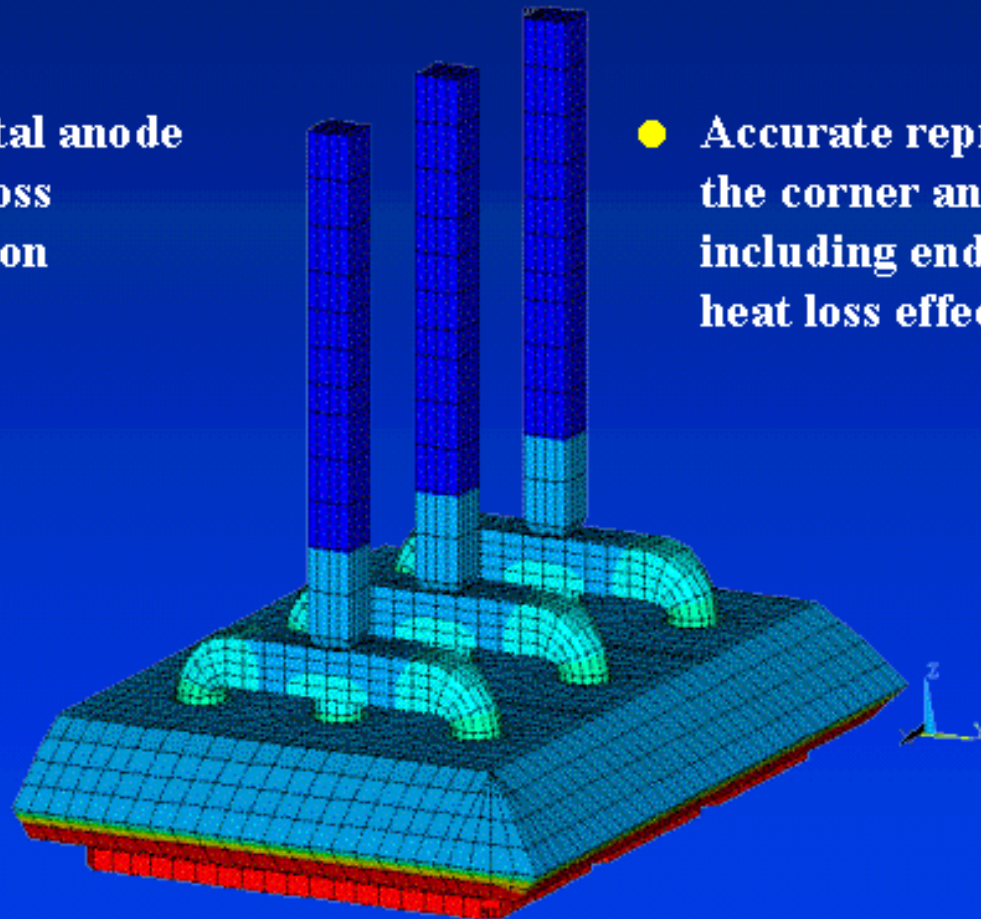GENISIM

The 3D Cathode Corner/Quarter Model
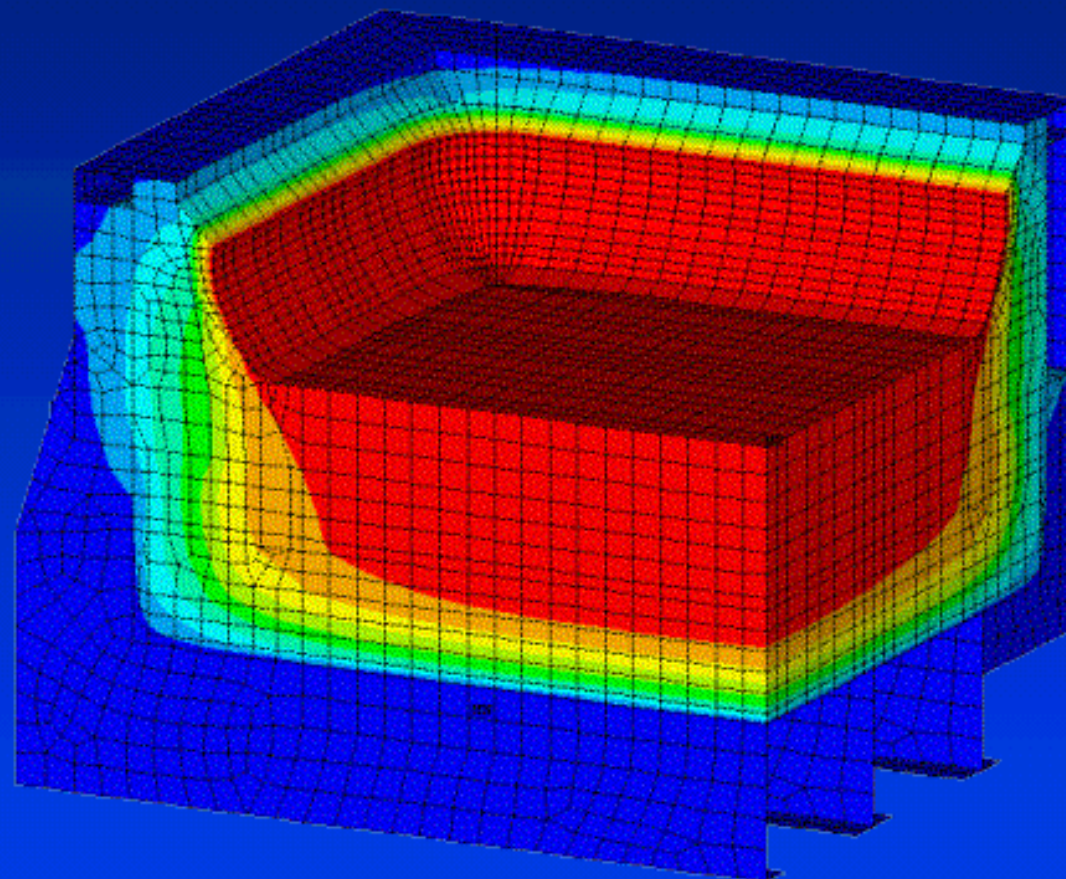
- Accurate representation of the end wall and corner heat loss

- Accurate corner ledge profile prediction

- Accurate total cathode heat loss representation

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The 3D Anode Panel Corner/Quarter Model

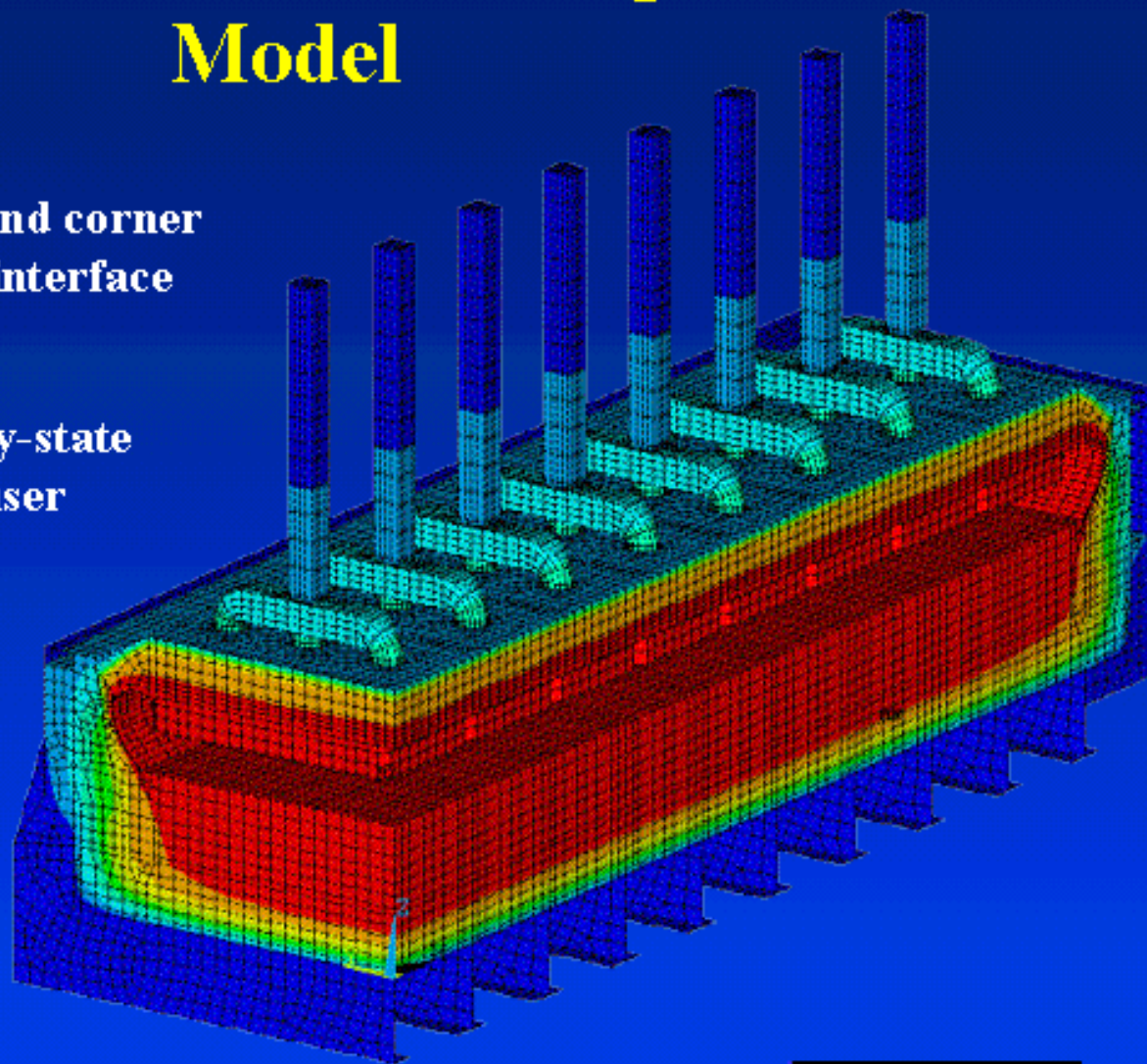- Accurate total anode panel heat loss representation

- Accurate representation of the corner anode heat loss by including end channel crust heat loss effect
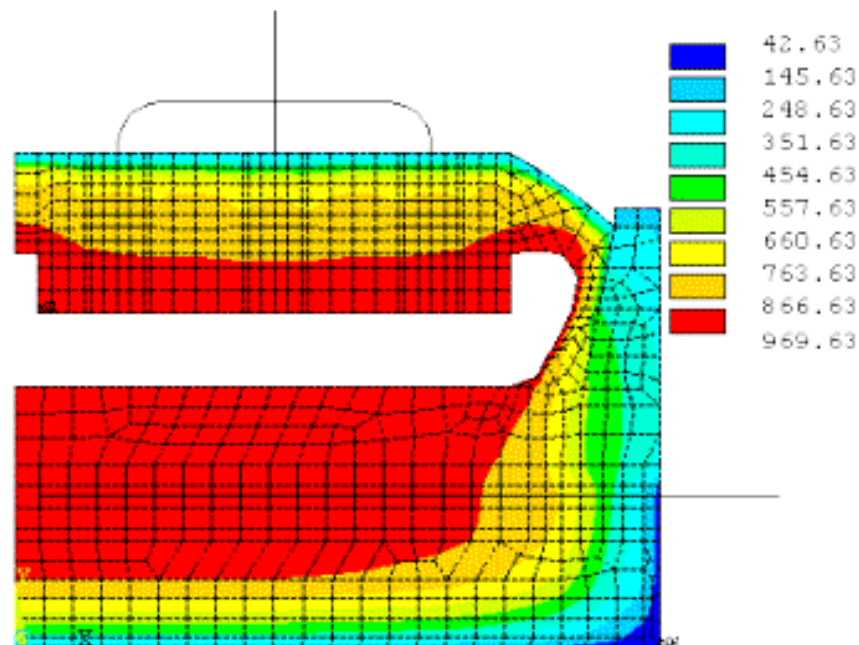

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The 3D Full Cell Corner/Quarter Model

- Accurate side, end and corner crust and top ledge interface representation

- Converged on steady-state conditions without user intervention

- Accurate total cell heat loss representation

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The 2D+ Full Cell Model

The 2D+ Full Cell Model

- Fairly accurate anode studs and rod voltage drop as well as heat loss representation

- Fairly accurate collector bar voltage drop and heat loss representation

- Fairly accurate cast iron to carbon contact resistance representation

- Accurate side channel crust and top ledge interface representation

- Converged on steady-state conditions without user intervention

- Fairly accurate total cell heat loss representation (rely on a good estimation of the cathode end wall heat loss)

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Models Comparison Summary Table

	Accurate bar & studs representation	Converged steady state automatically	No feed for extrapolation	Converge legde profile	Less than 5 minutes to solve
Classic 2D		√		√	√
3D Half Anode	√				√
3D Cathode Slice	√			√	√
3D Full Cell Slice	√	√		√	
3D Cathode Quarter	√		√	√	
3D Anode Panel Quarter	√		√		
3D Full Cell Quarter	√	√	√	√	
2D+ Full Cell	√	√		√	√

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Conclusions

- By adding the simple 1D model developed to quickly answer "what if scenario" questions in brainstorming session, that was not covered in this paper, this gives to cell designers 8 models to choose from ranging from the fastest to the most accurate

- All those models and the know-how they represent are commercially available to the whole industry

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