# Retrofit of a 500 kA Cell Design into a 600 kA Cell Design

**Marc Dupuis**

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GENISIM

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*School of Computing and Mathematics*

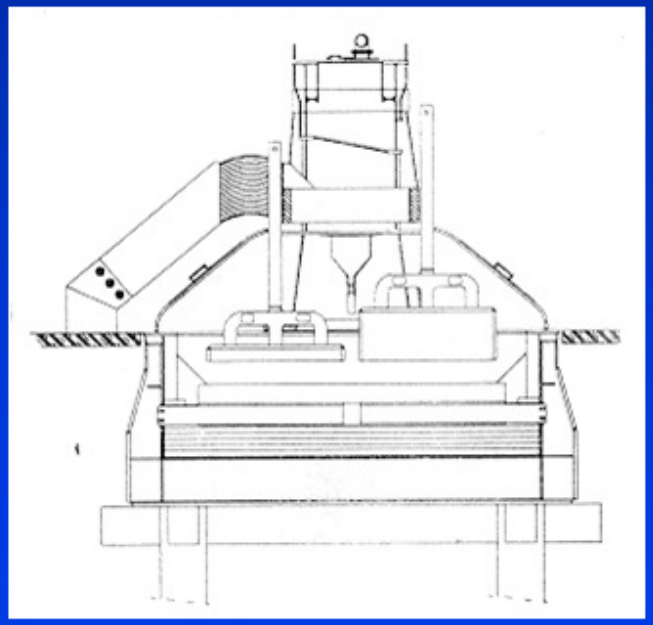
# Plan of the Presentation

- Introduction
- Review of the 500 kA Cell Busbar Designs
- New Anode Stub Hole TEM Model and Anode Design
- New Cathode Collector Bar Slot TEM Model and Cathode Design
- Full Cell Quarter Model Including the Liquid Zone
- Calculation of the Retrofitted Cell Amperage Using Dyna/Marc
- Verification of the Thermal Balance at 600 kA Using the ANSYS® based TE Models
- Verification of the MHD Stability at 600 kA Using MHD-Valdis
- Conclusions

# Introduction

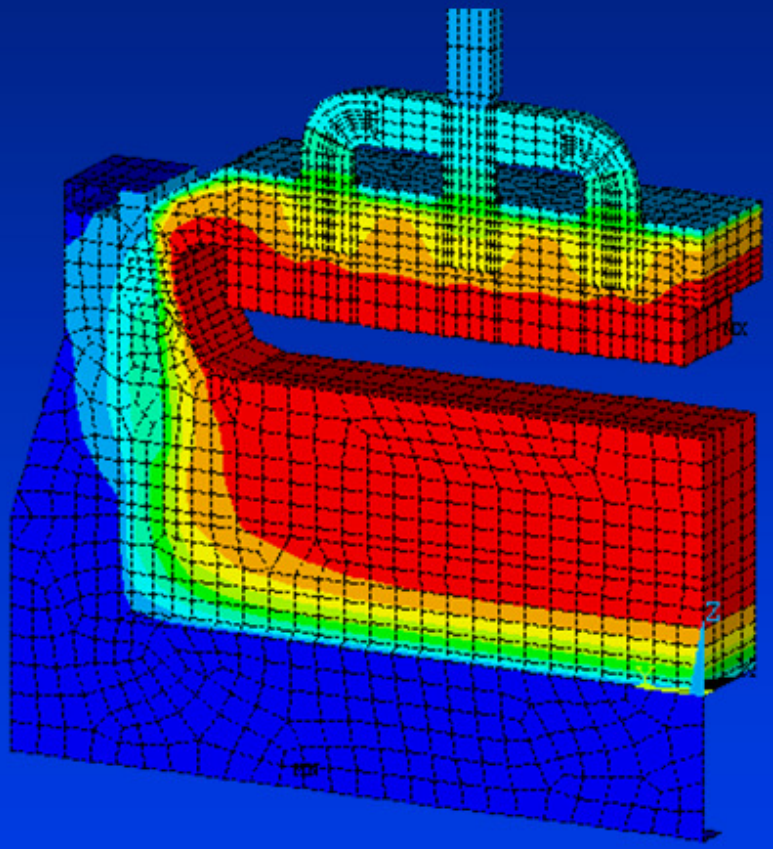
- In 2000, the first author has presented the retrofit of a 300 kA cell design into a 350 kA cell design and then by extending the length of the potshell, a new 400 ka cell thermo-electric design.
- Then in 2003, by further extending the length and this time by also slightly increasing the potshell width, the first author has presented a new 500 kA cell thermo-electric design.
- Later in 2005, still extending the length of the 500 kA cell potshell, the same author presented a new 740 kA cell thermo-electric design and claimed that there is no foreseeable limit to a cell size as far as the thermo-electric cell heat balance aspect of the cell design is concerned.
- Finally in 2005-2006, the authors have presented both the MHD and the potshell mechanical designs of the 500 and 740 kA cells claiming that there seems to be no foreseeable limit to the cell size as far as the MHD and potshell mechanical design aspects of the cell design are concerned.

# Base Case 300 kA Cell Design



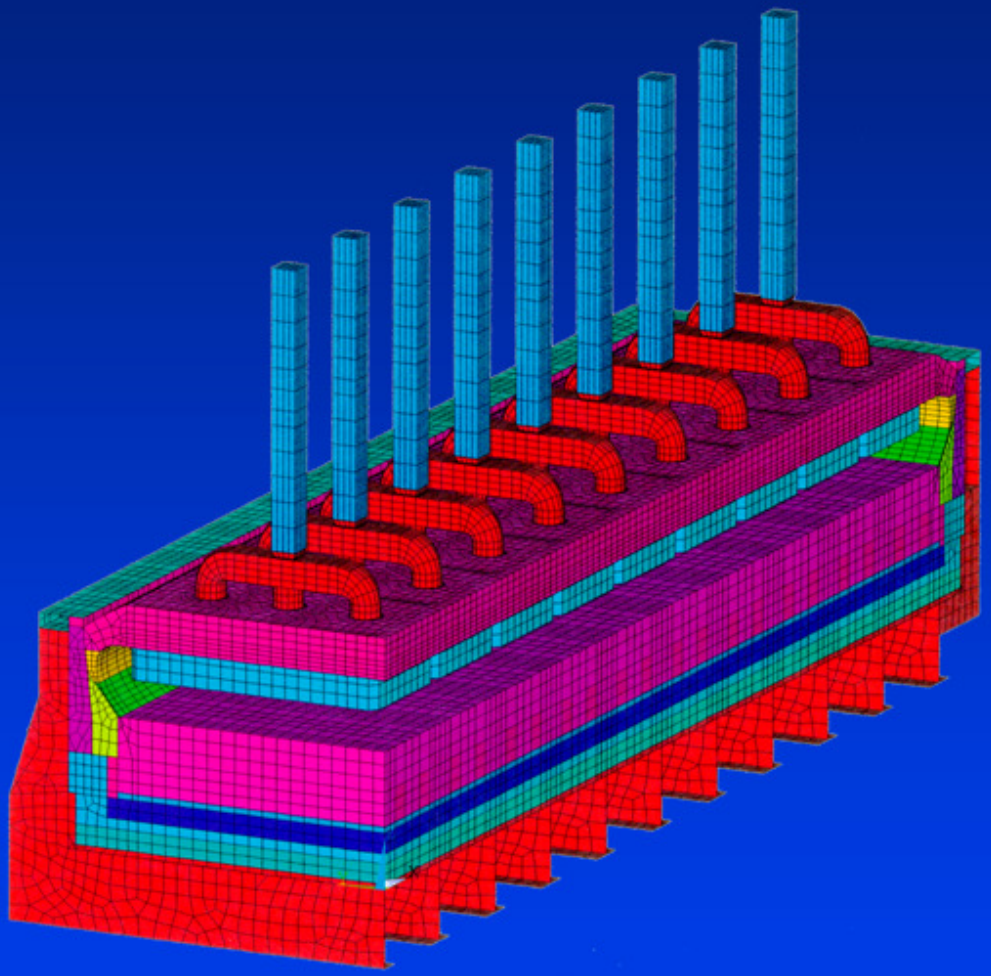
| | |
|---|---|
| Amperage | 300 kA |
| Nb. of anodes | 32 |
| Anode size | 1.6 m X 0.8 m |
| Nb. of anode studs | 3 per anode |
| Anode stud diameter | 18 cm |
| Anode cover thickness | 16 cm |
| Nb. of cathode blocks | 18 |
| Cathode block length | 3.47 m |
| Type of cathode block | 30 % graphitic |
| Type of side block | 30 % graphitic |
| Side block thickness | 15 cm + |
| ASD and AED | 35 cm |
| Inside potshell size | 14.4 m X 4.35 m |
| ACD | 5 cm |
| Excess $AlF_3$ | 10.9 % |
| Operating temperature | 973.3 °C |
| Liquidus superheat | 6.8 °C |
| Current efficiency | 94.0 % |
| Internal heat | 628 kW |
| Energy consumption | 13.75 kWh/kg |

# Retrofitted 350 kA Cell Design



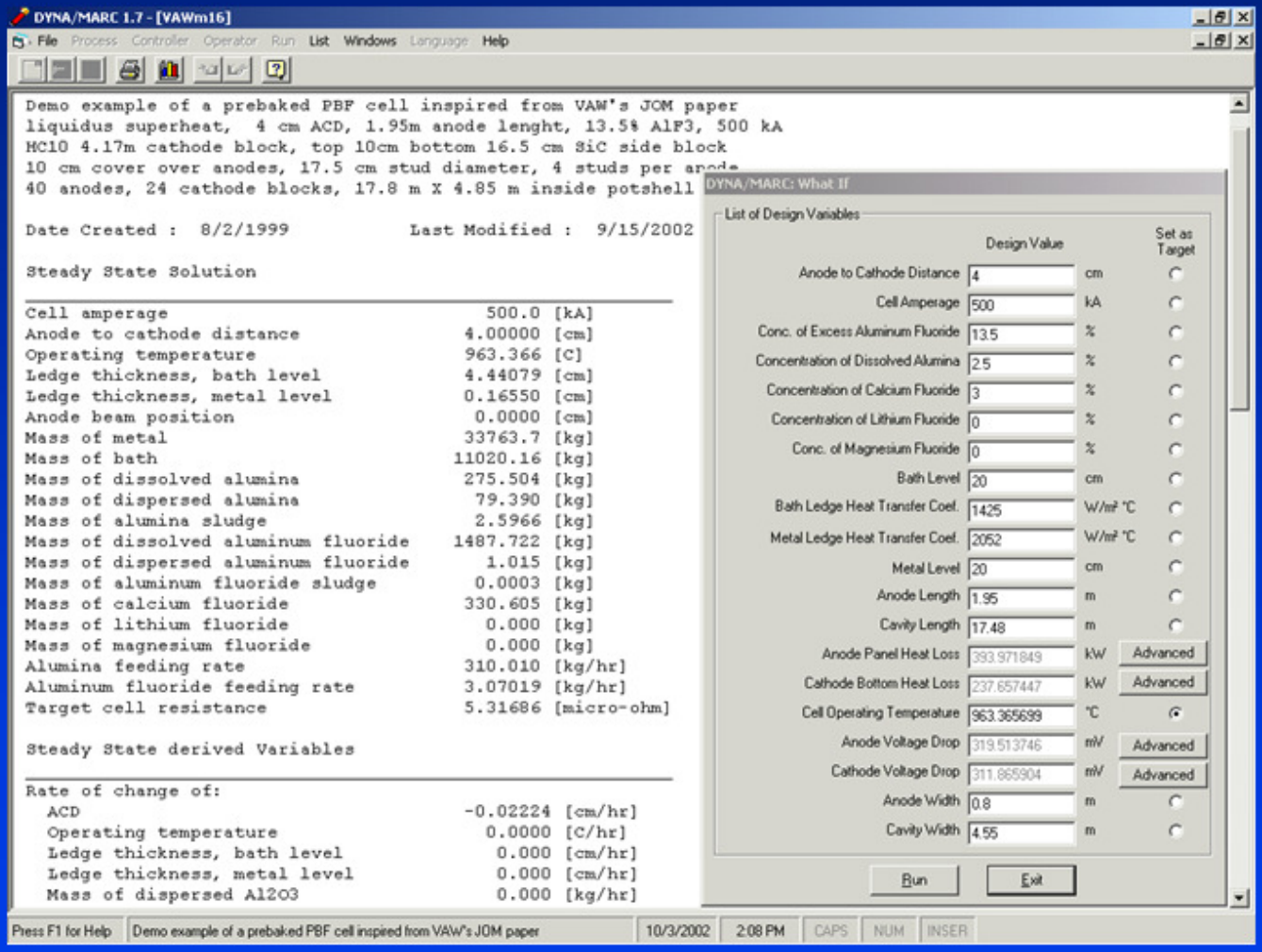
| | |
|---|---|
| Amperage | 350 kA |
| Nb. of anodes | 32 |
| Anode size | 1.7 m X 0.8 m |
| Nb. of anode studs | 3 per anode |
| Anode stud diameter | 19 cm |
| Anode cover thickness | 10 cm |
| Nb. of cathode blocks | 18 |
| Cathode block length | 3.67 m |
| Type of cathode block | 100 % graphitized |
| Type of side block | Silicon carbide |
| Side block thickness | 10 cm + |
| ASD | 30 cm |
| Inside potshell size | 14.4 m X 4.35 m |
| ACD | 4 cm |
| Excess $AlF_3$ | 13.5 % |
| Operating temperature | 960.4 °C |
| Liquidus superheat | 6.7 °C |
| Current efficiency | 96.1 % |
| Internal heat | 713 kW |
| Energy consumption | 13.4 kWh/kg |

# Greenfield 400 kA Cell Design



| | |
|---|---|
| Amperage | 400 kA |
| Nb. of anodes | 36 |
| Anode size | 1.6 m X 0.8 m |
| Nb. of anode studs | 3 per anode |
| Anode stud diameter | 19 cm |
| Anode cover thickness | 10 cm |
| Nb. of cathode blocks | 20 |
| Cathode block length | 3.67 m |
| Type of cathode block | 100 % graphitized |
| Type of side block | Silicon carbide |
| Side block thickness | 10 cm + |
| ASD and AED | 30 cm |
| Inside potshell size | 16.1 m X 4.35 m |
| ACD | 4 cm |
| Excess $AlF_3$ | 13.5 % |
| Operating temperature | 962.4 °C |
| Liquidus superheat | 8.7 °C |
| Current efficiency | 96.0 % |
| Internal heat | 834 kW |
| Energy consumption | 13.6 kWh/kg |

# Greenfield 500 kA Cell Design




| | |
|---|---|
| Amperage | 500 kA |
| Nb. of anodes | 40 |
| Anode size | 1.95 m X 0.8 m |
| Nb. of anode studs | 4 per anode |
| Anode stud diameter | 17.5 cm |
| Anode cover thickness | 10 cm |
| Nb. of cathode blocks | 24 |
| Cathode block length | 4.17 m |
| Type of cathode block | HC10 |
| Type of side block | SiC |
| Side block thickness | 10 cm + |
| ASD | 30 cm |
| Inside potshell size | 17.8 X 4.85 m |
| ACD | 4 cm |
| Excess $AlF_3$ | 13.5 % |

| | |
|---|---|
| Anode drop | 320 mV |
| Cathode drop | 312 mV |
| Anode panel heat loss | 394 kW |
| Cathode bottom heat loss | 238 kW |
| Operating temperature | 963.4 °C |
| Liquidus superheat | 9.7 °C |
| Bath ledge thickness | 4.44 cm |
| Metal ledge thickness | 0.17 cm |
| Current efficiency | 95.9 % |
| Internal heat | 1019 kW |
| Energy consumption | 13.39 kWh/kg |

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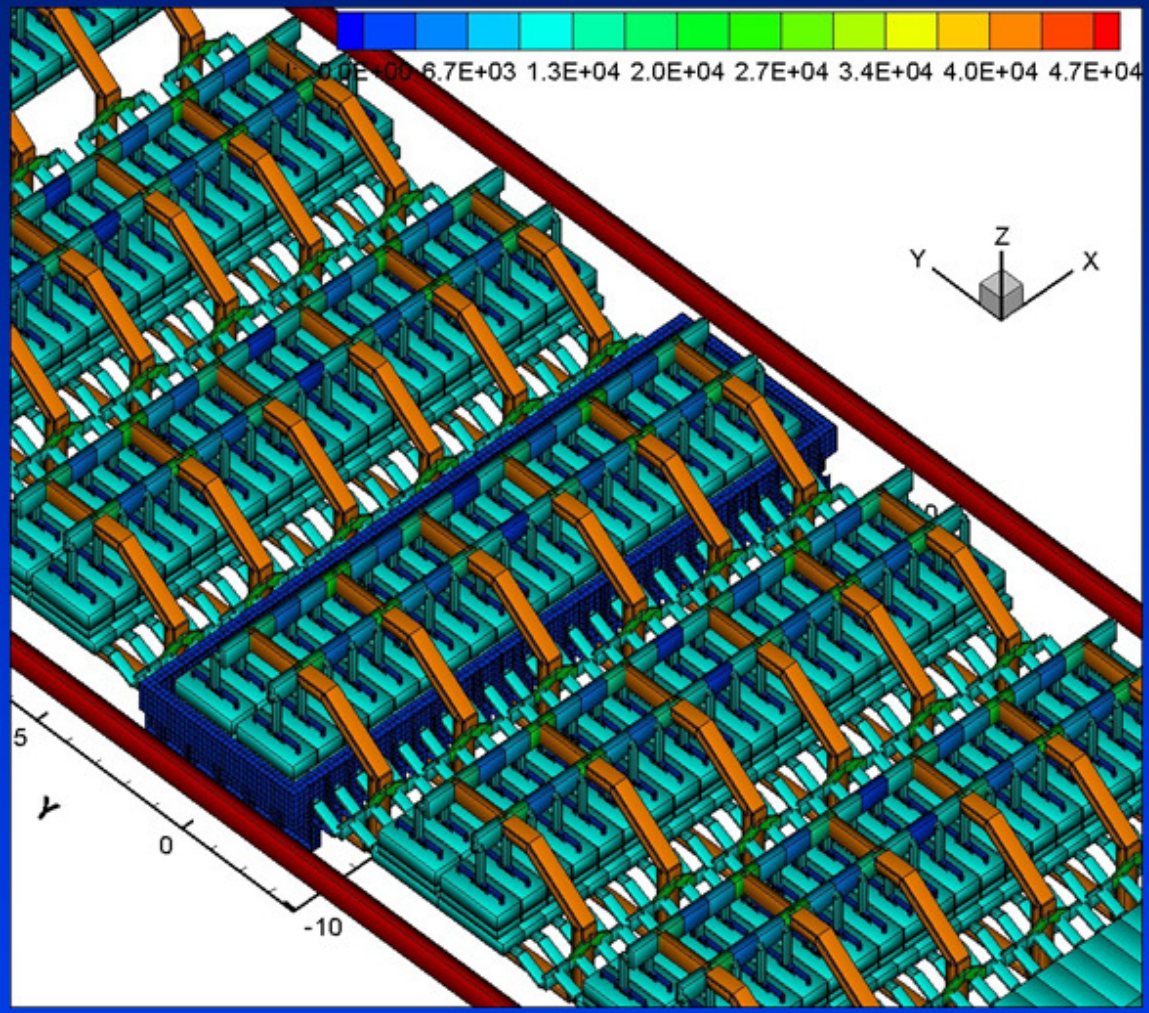
# Busbar Design of the 500 kA Cell

Busbar design inspired from the Pechiney 1987 busbar patent

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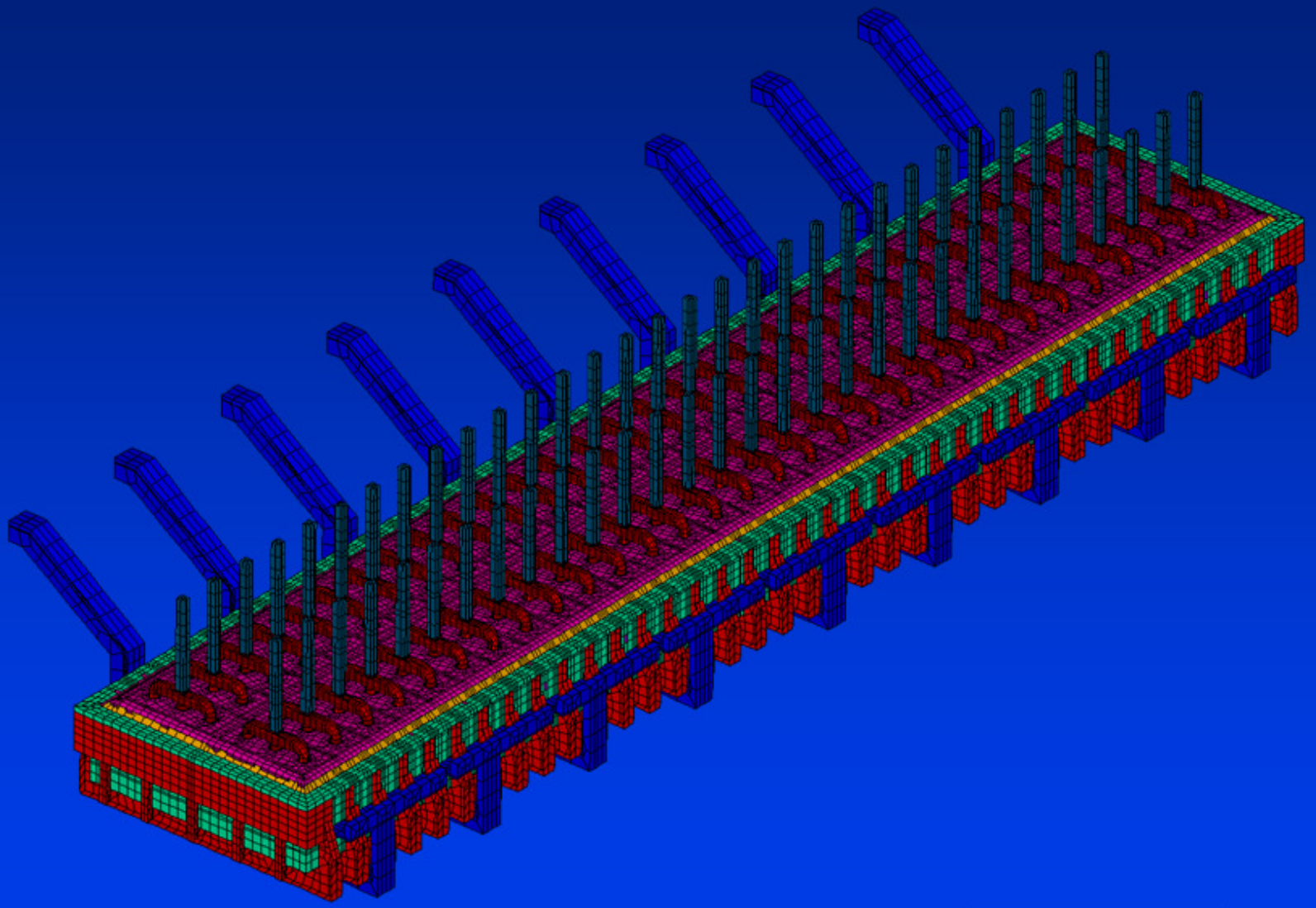
# Greenfield 740 kA Cell Design



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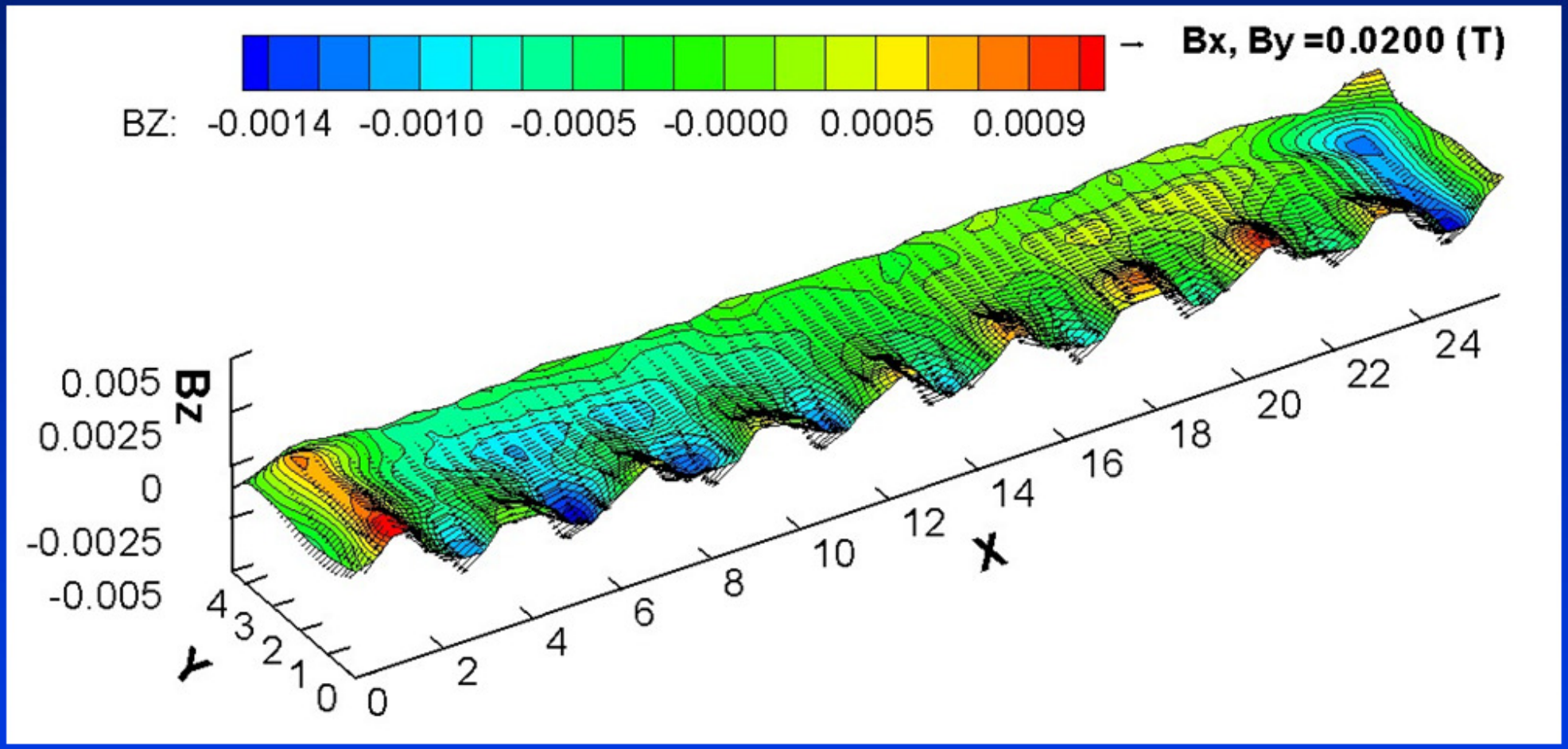
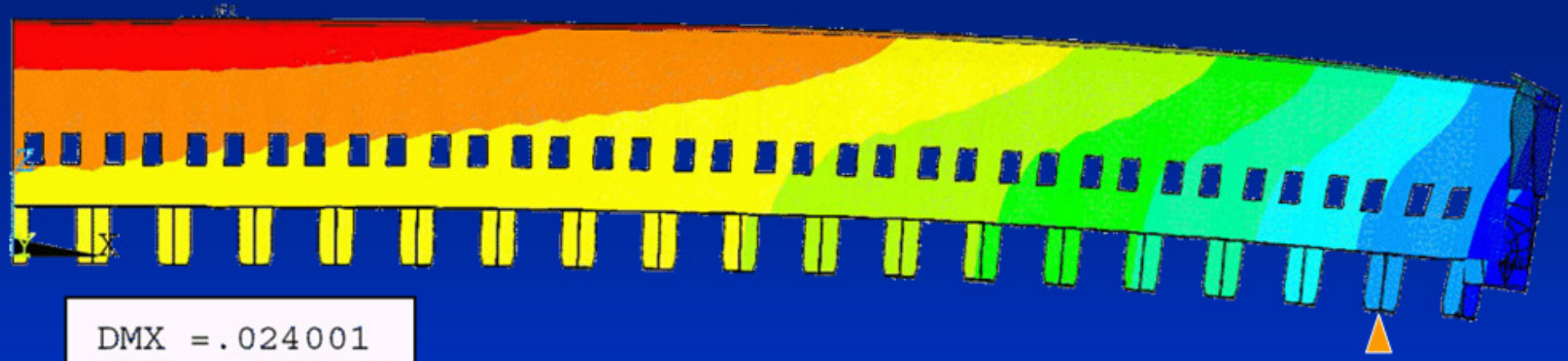
# Greenfield 740 kA cell MHD Model Results




No global Bz longitudinal gradient, so no MHD instability wave

# 740 kA Cell Potshell Mechanical Model Results




Relative Vertical Displacement for the Fine Mesh Model

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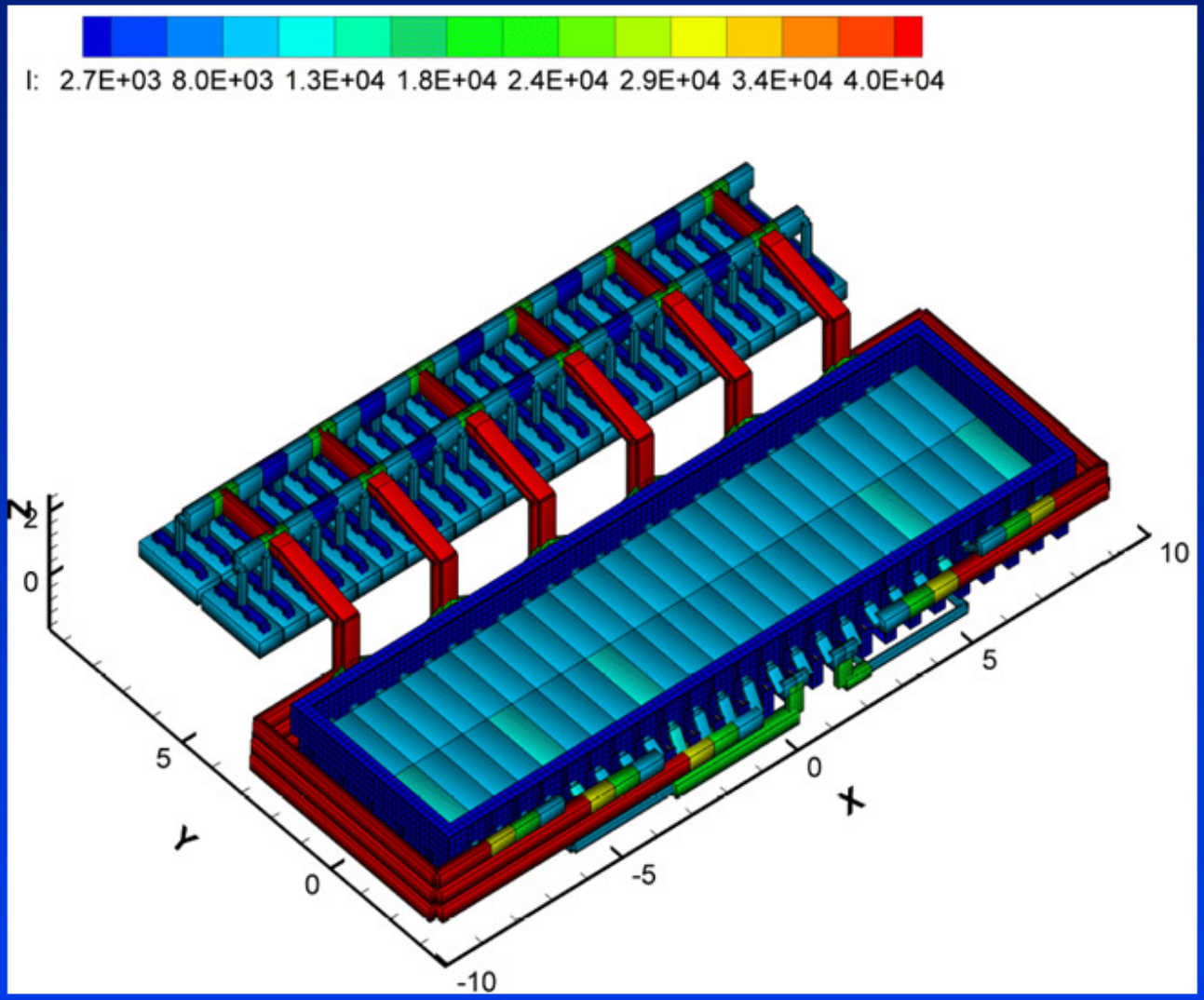
# Review of the 500 kA Cell Busbar Designs

Design no 1:

"classical"
asymmetric

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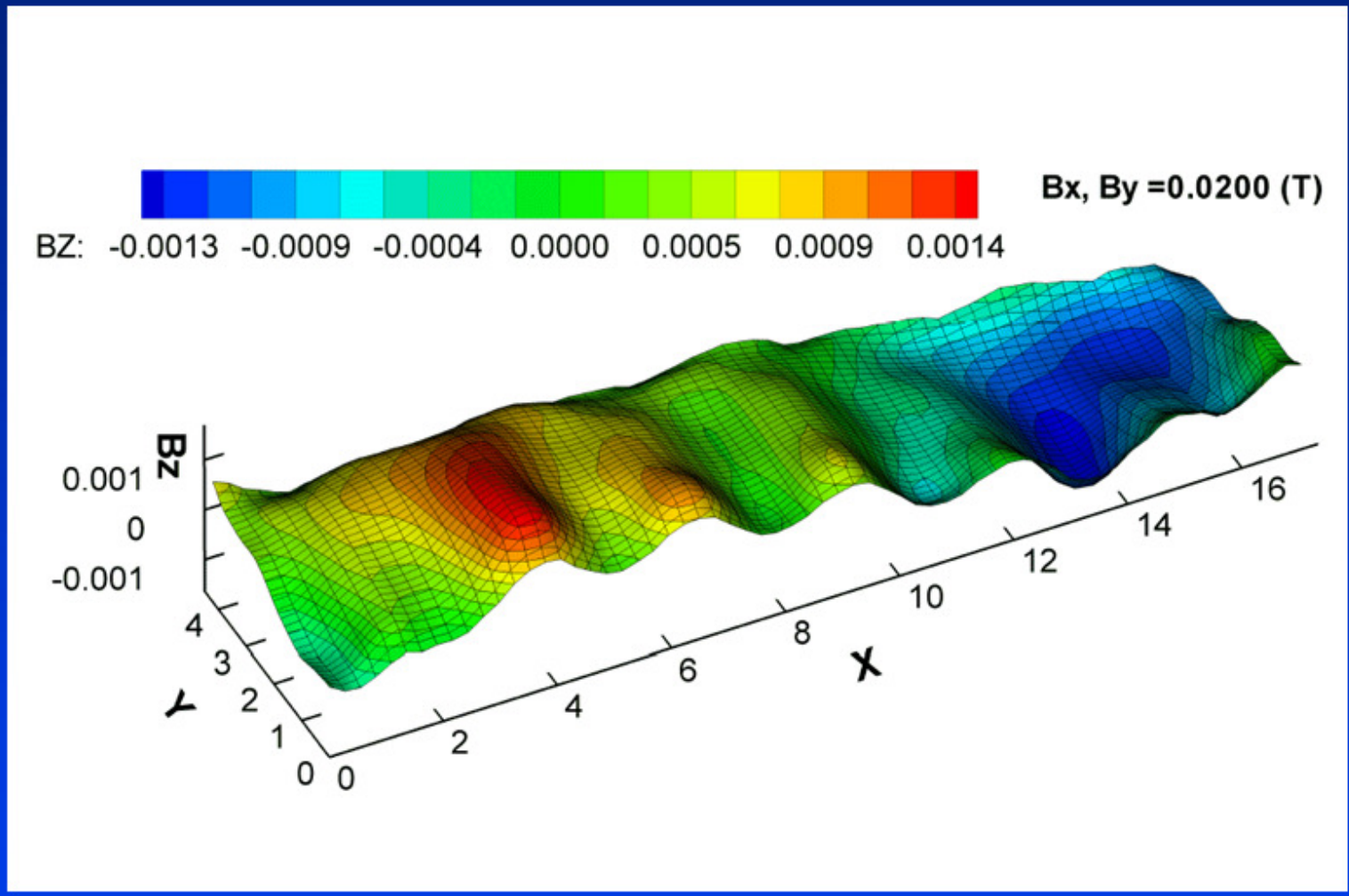

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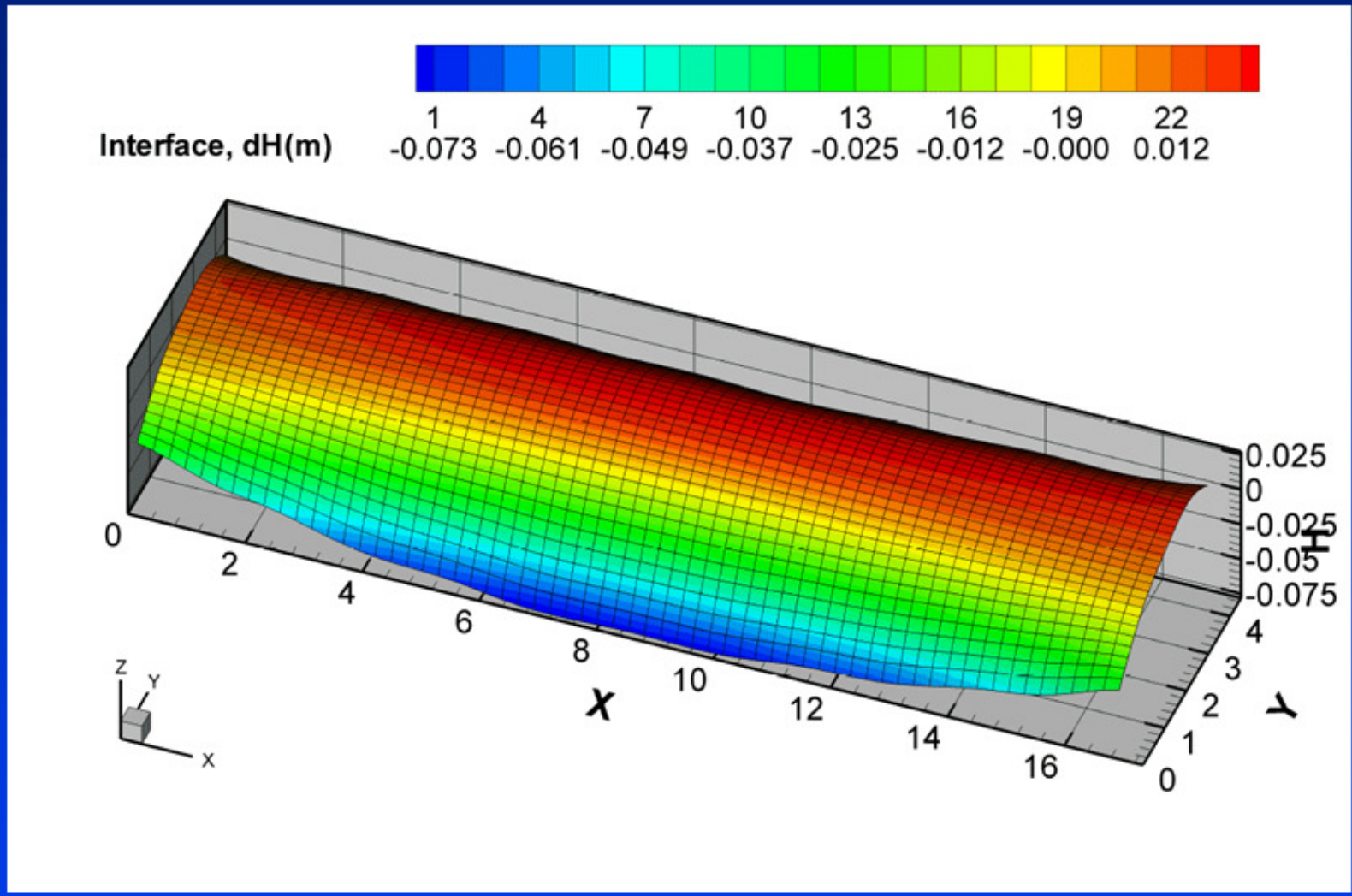

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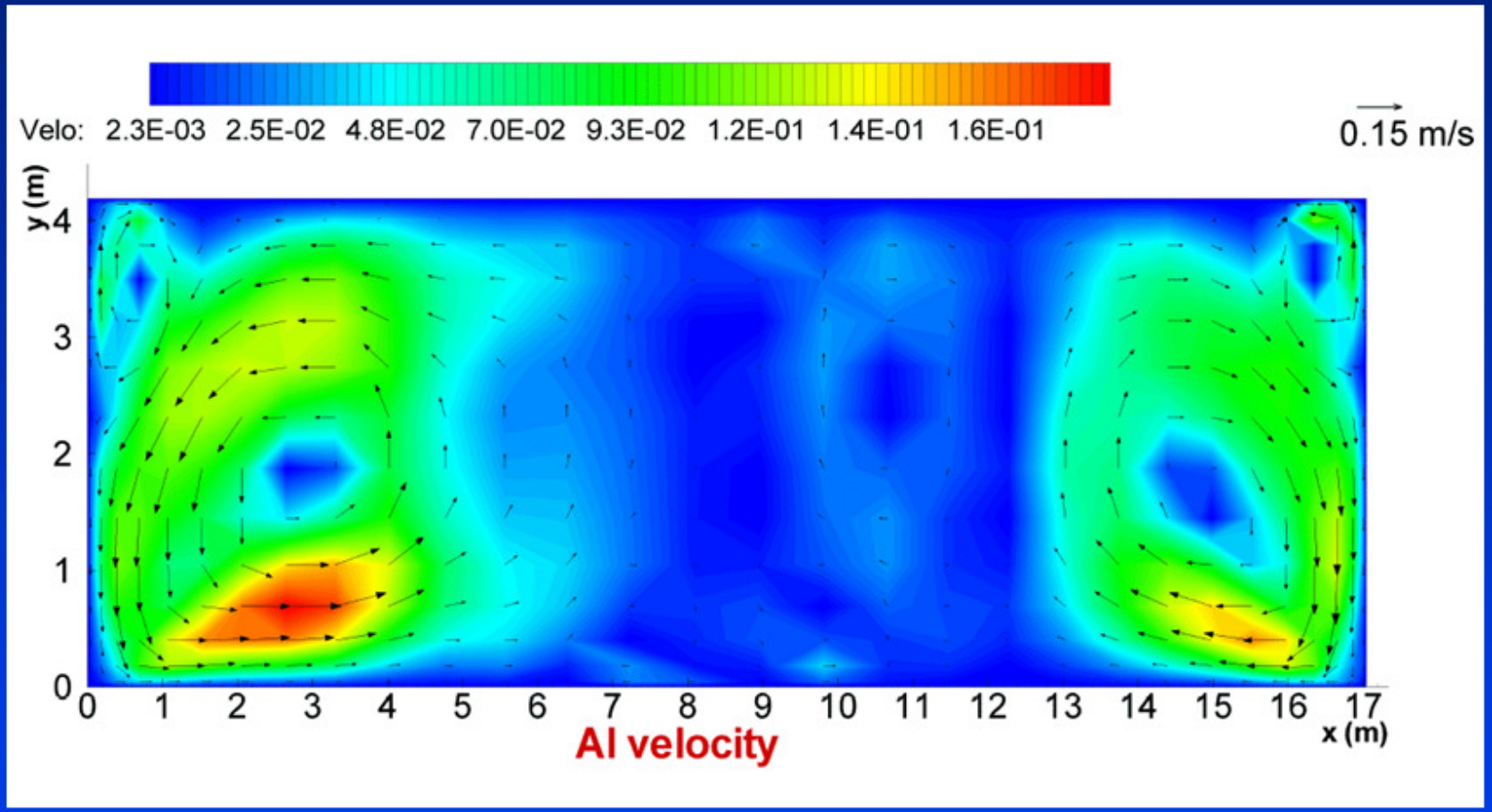


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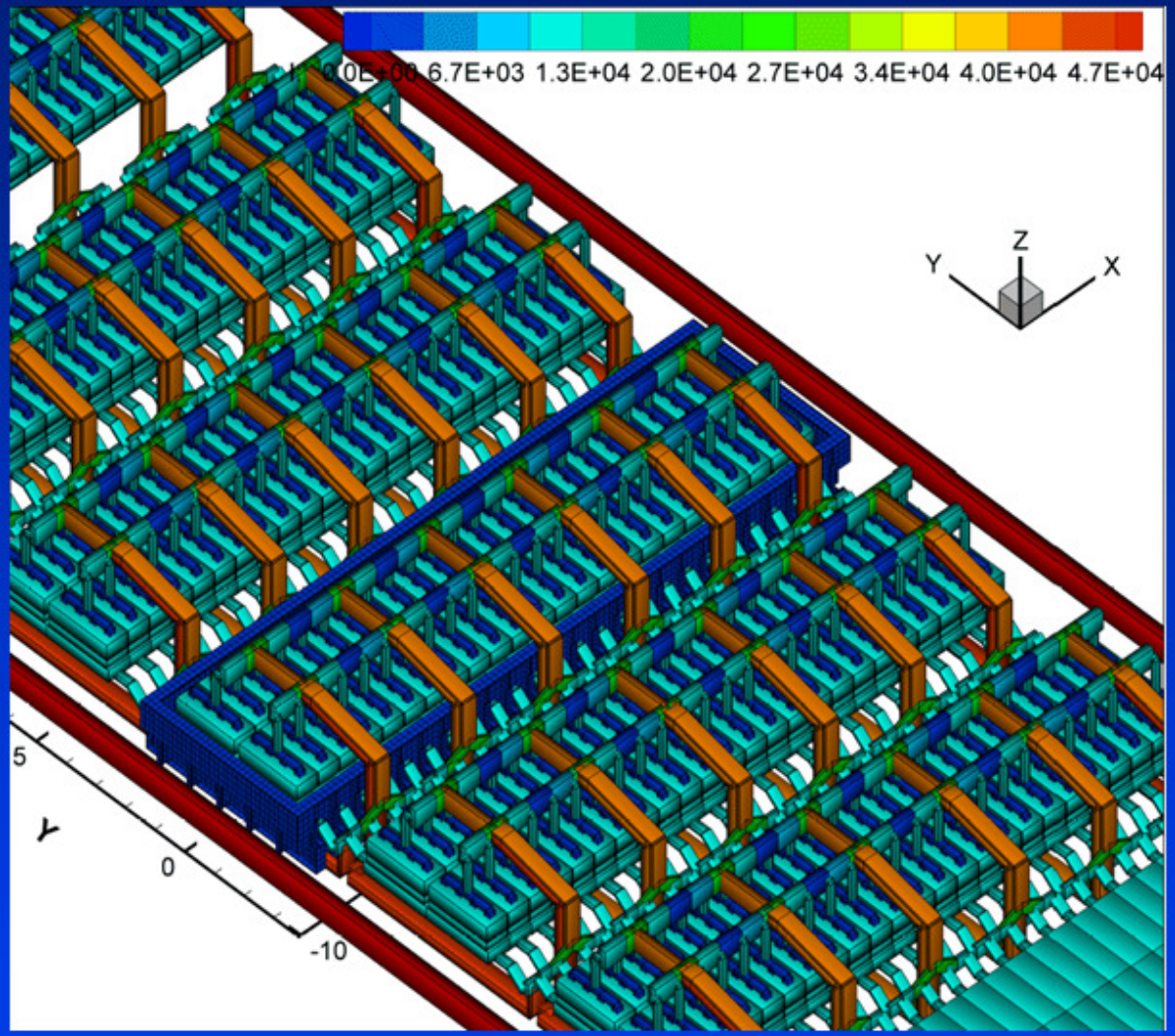
# Review of the 500 kA Cell Busbar Designs

Design no 2:

inspired from the Pechiney 1987 busbar patent



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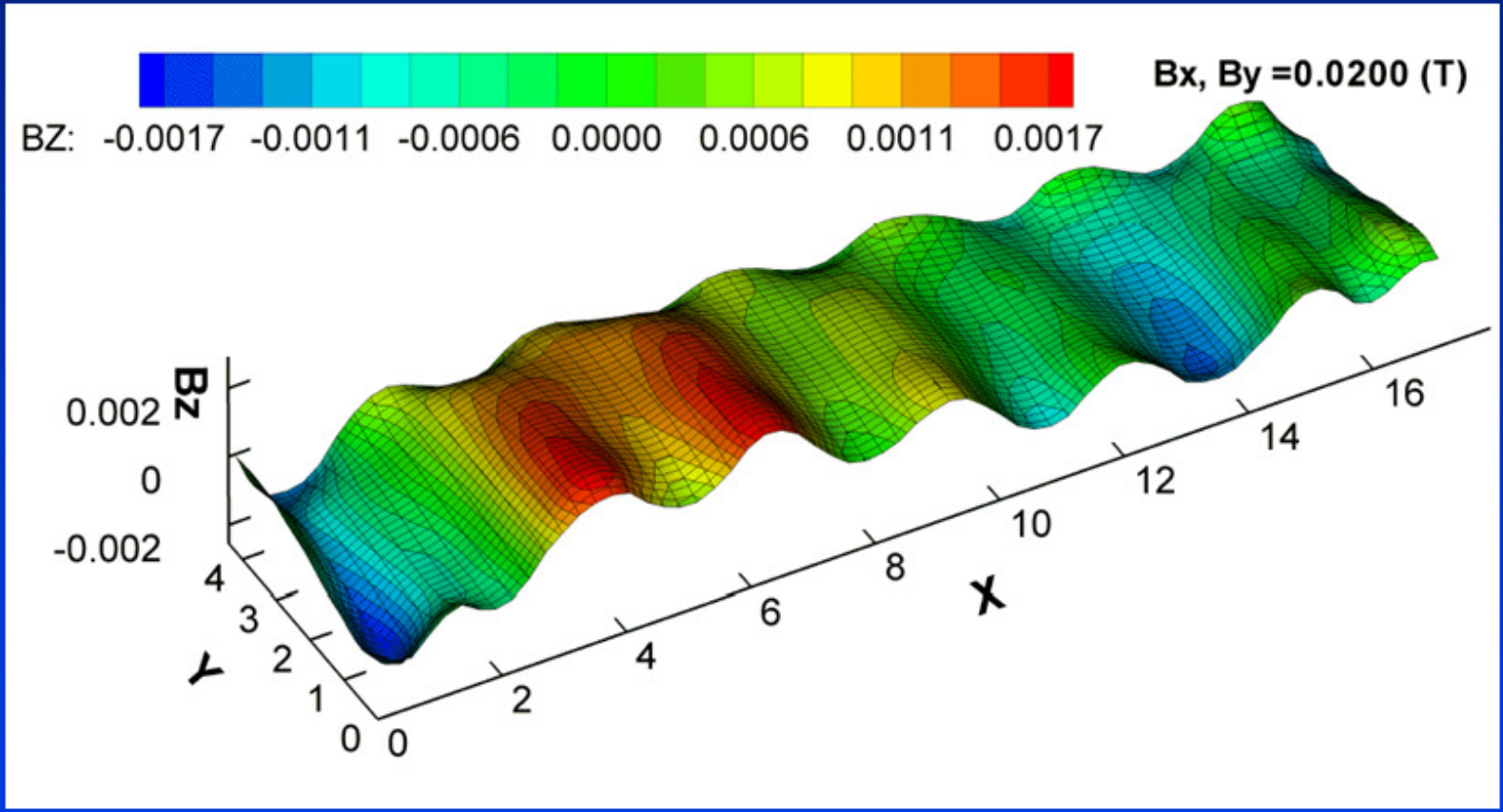

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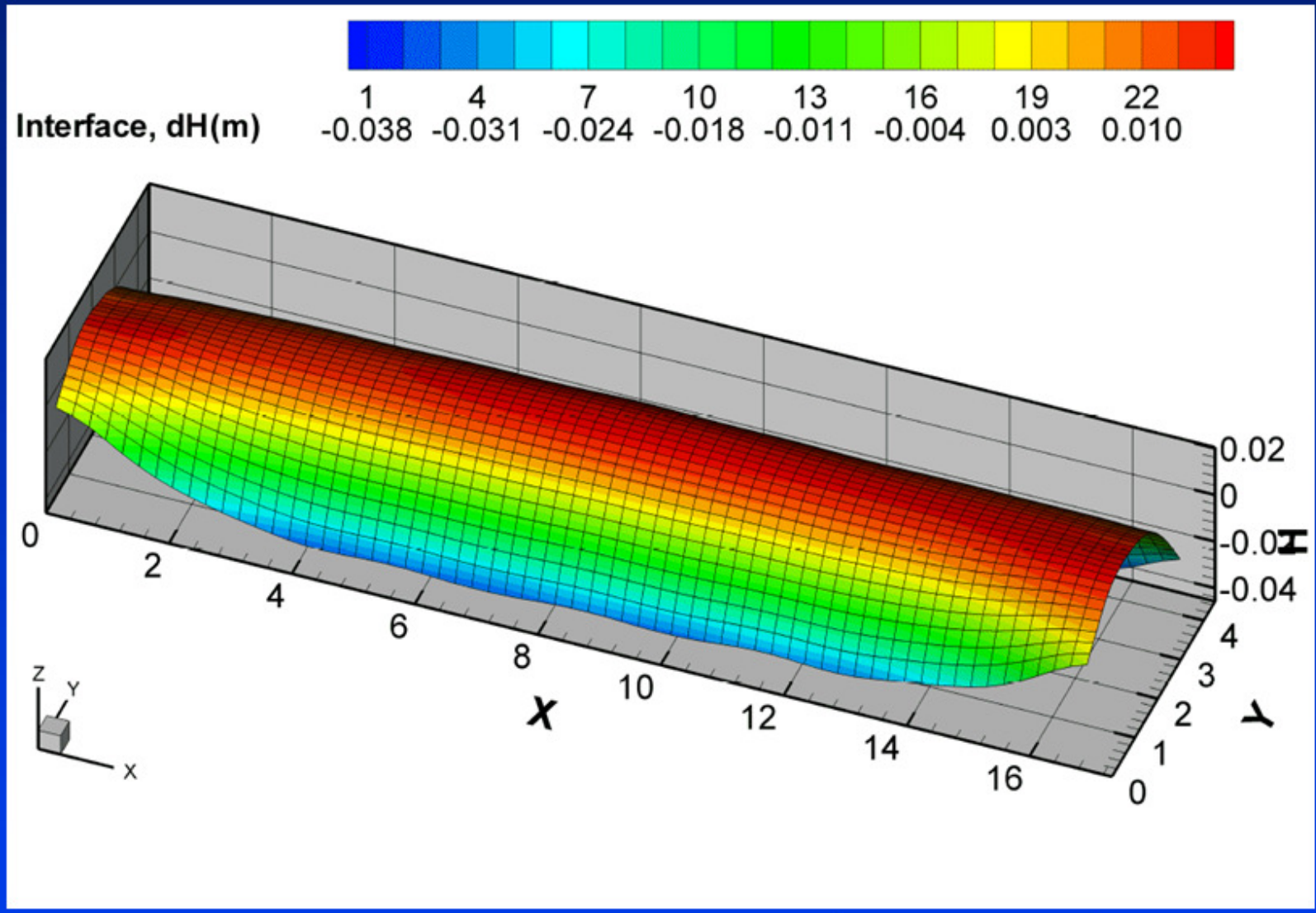

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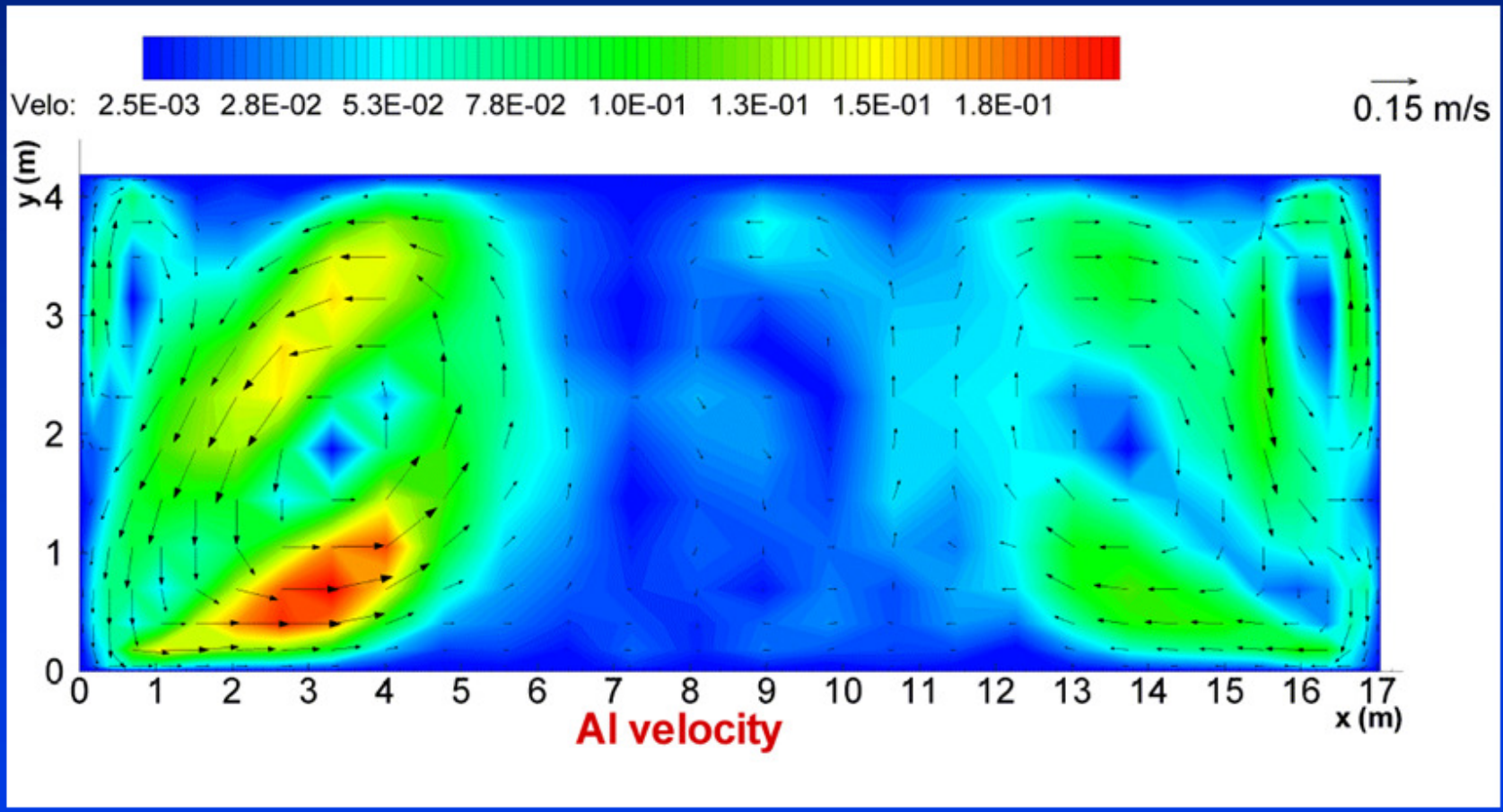


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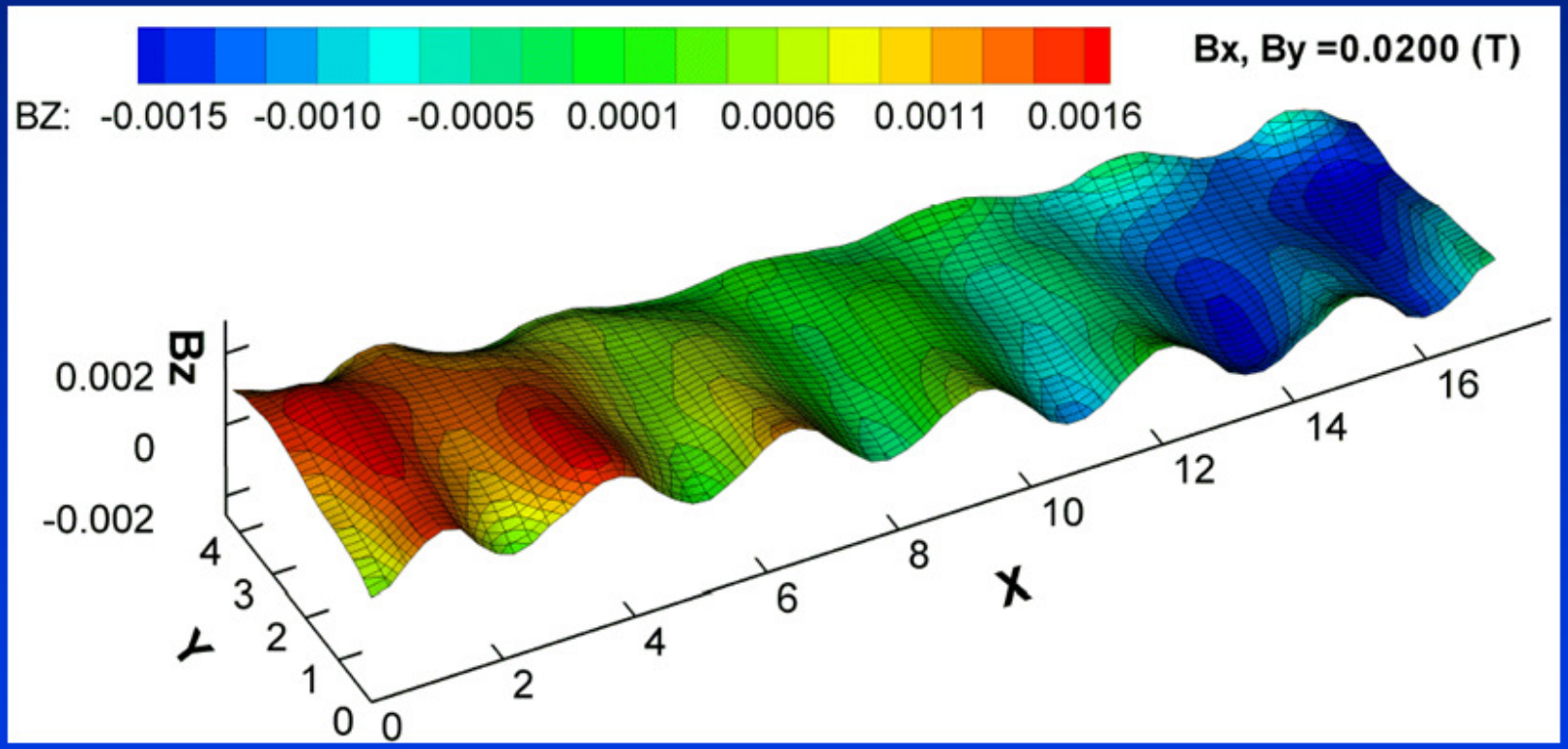
# Review of the 500 kA Cell Busbar Designs

Design no 3:

Alternative compensation busbar



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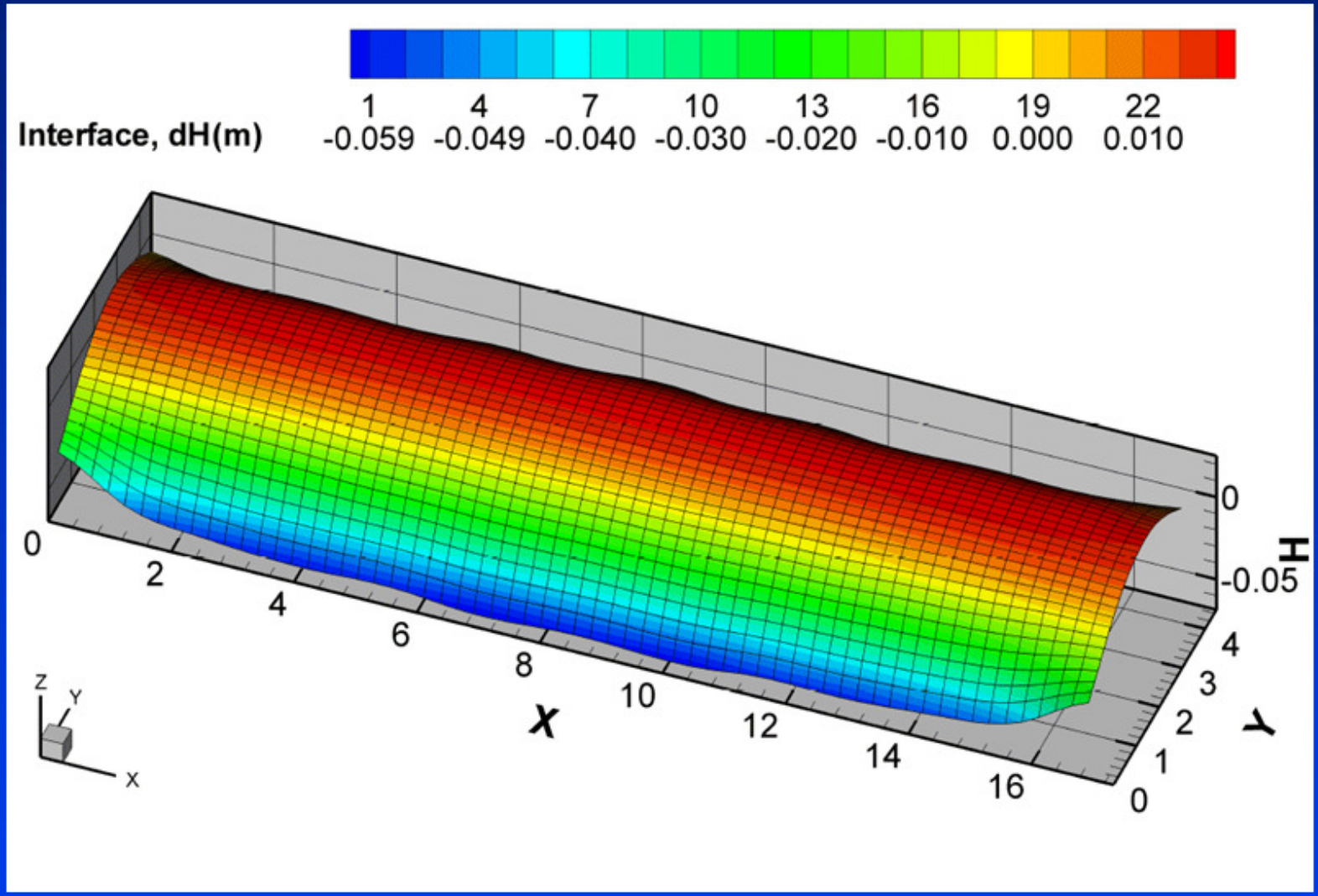


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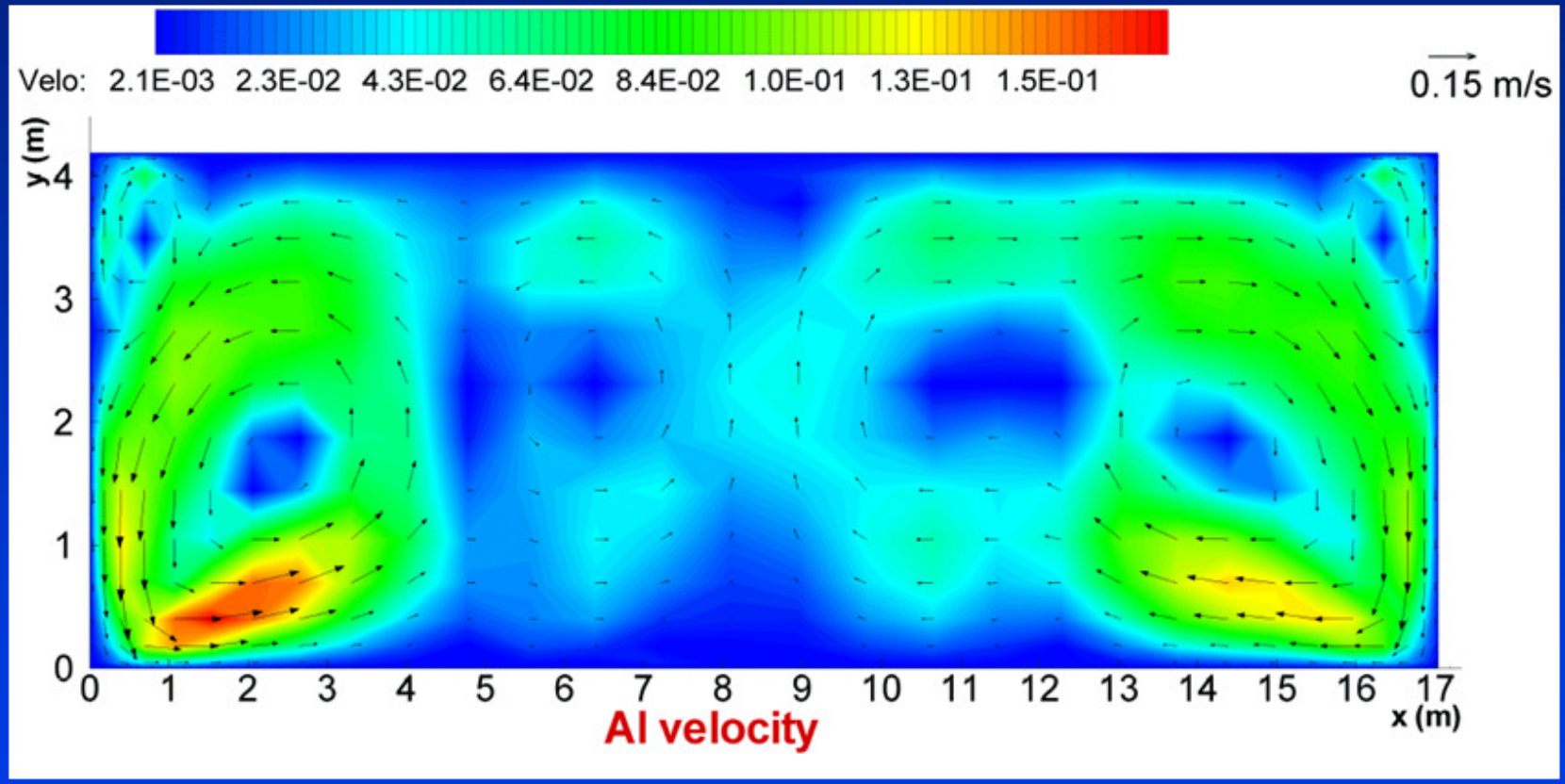


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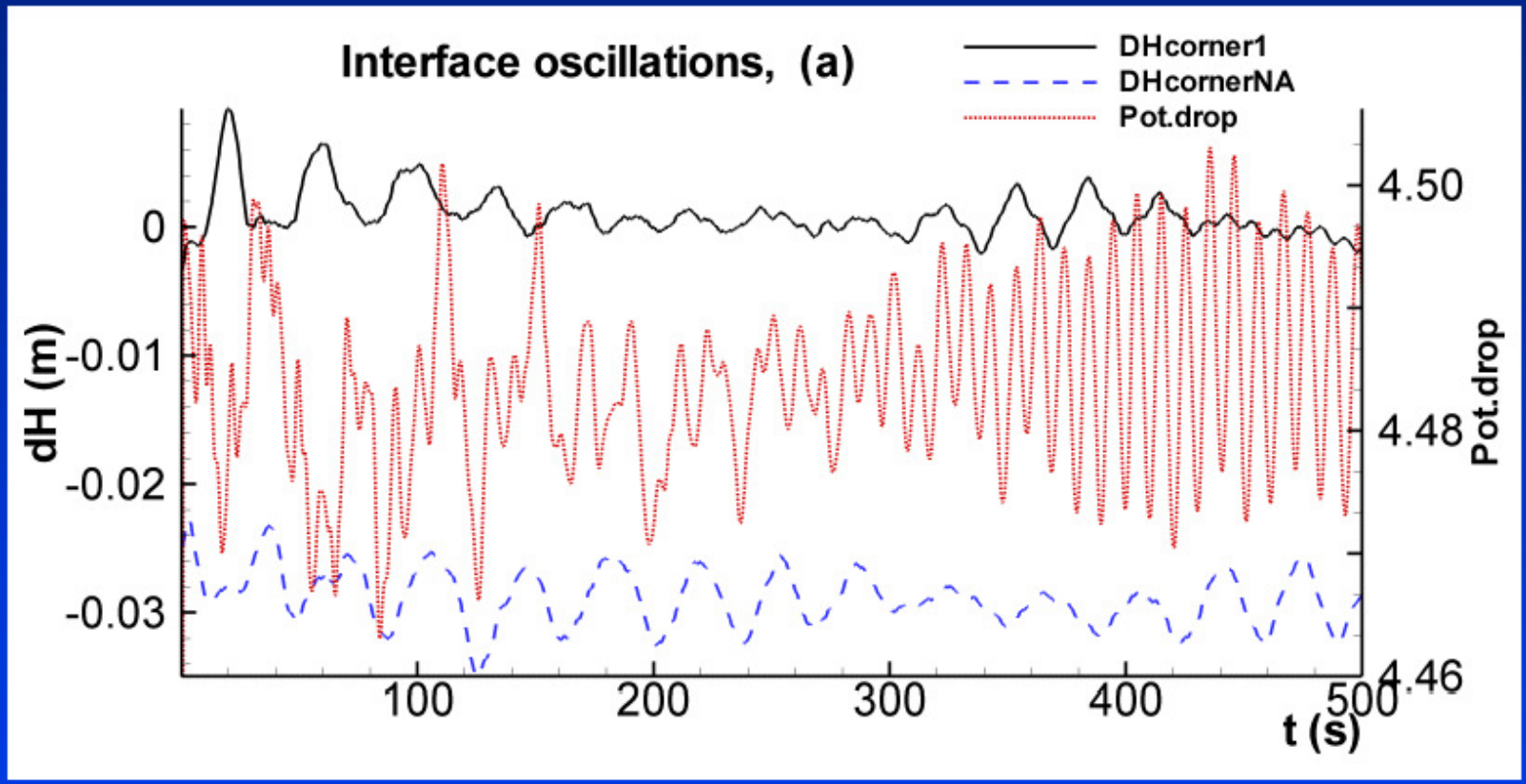


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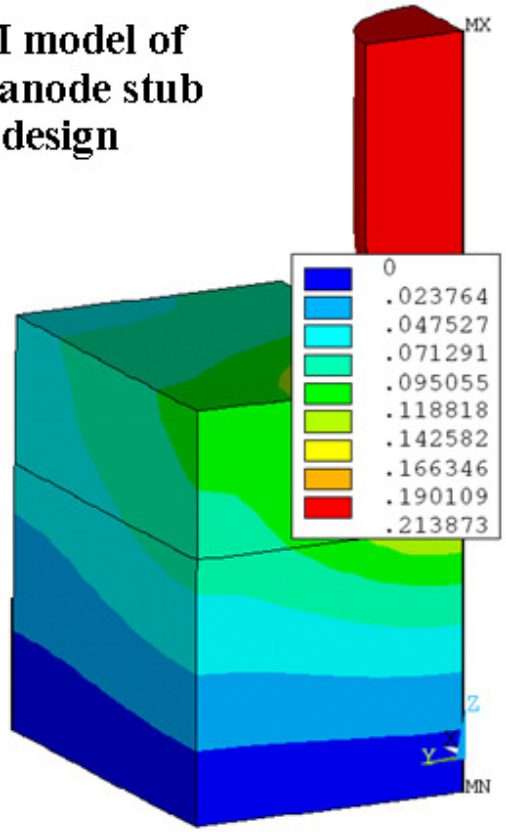
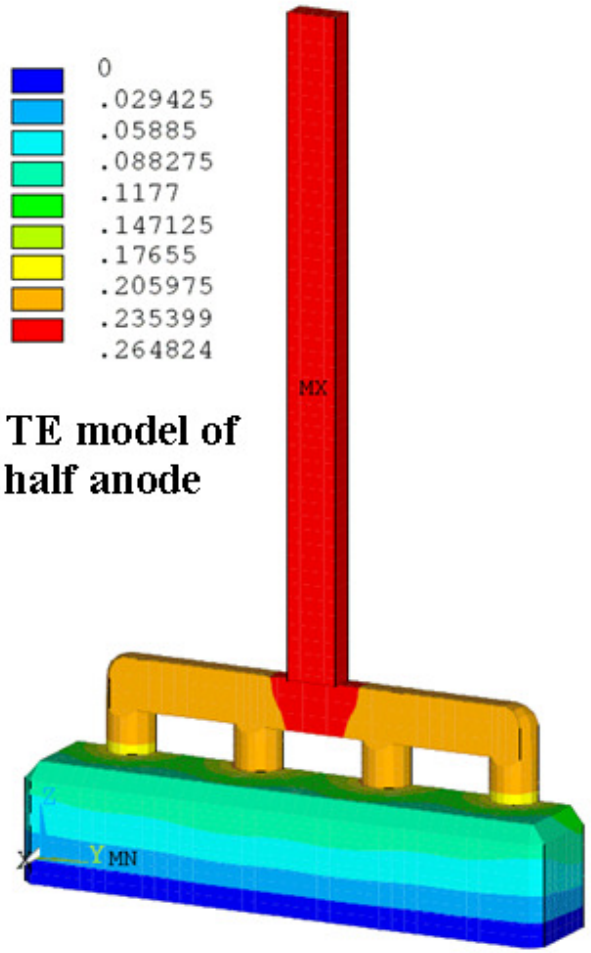
# New Anode Stub Hole TEM Model and Anode Design

TEM model of new anode stub hole design




TE model of half anode

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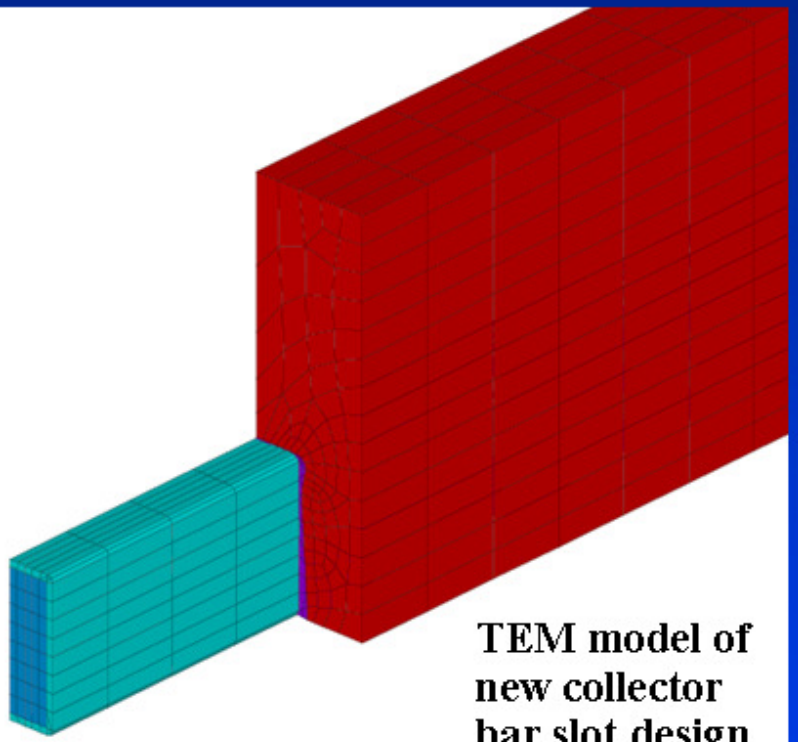
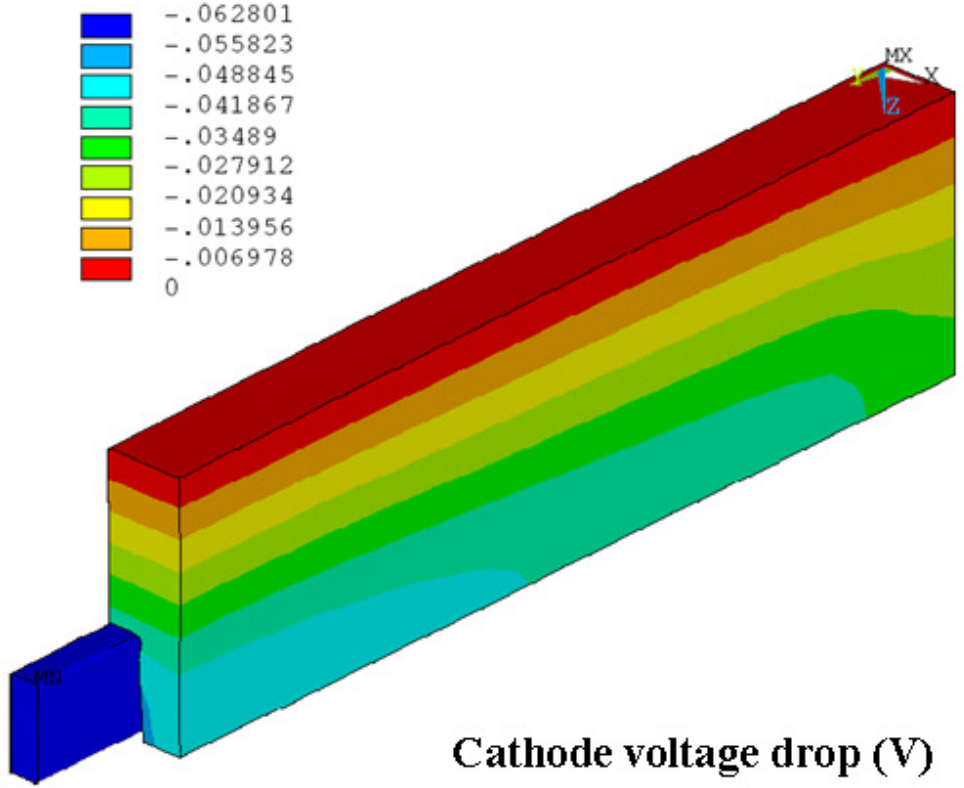
# New Cathode Collector Bar Slot TEM Model and Cathode Design

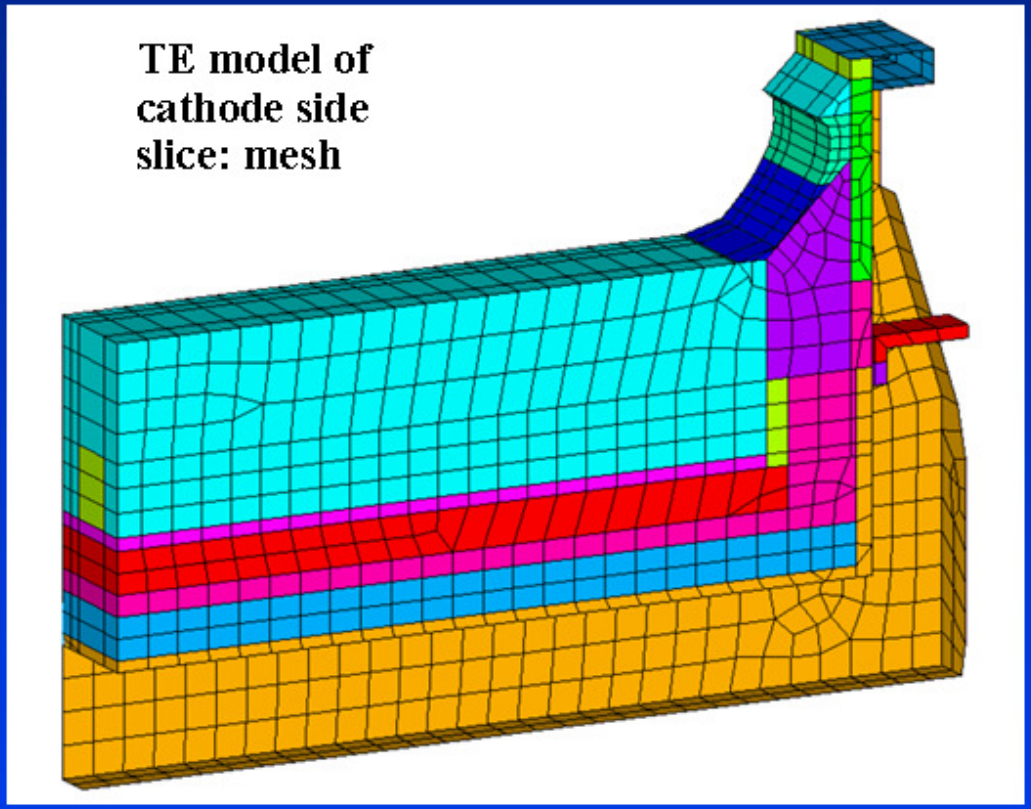


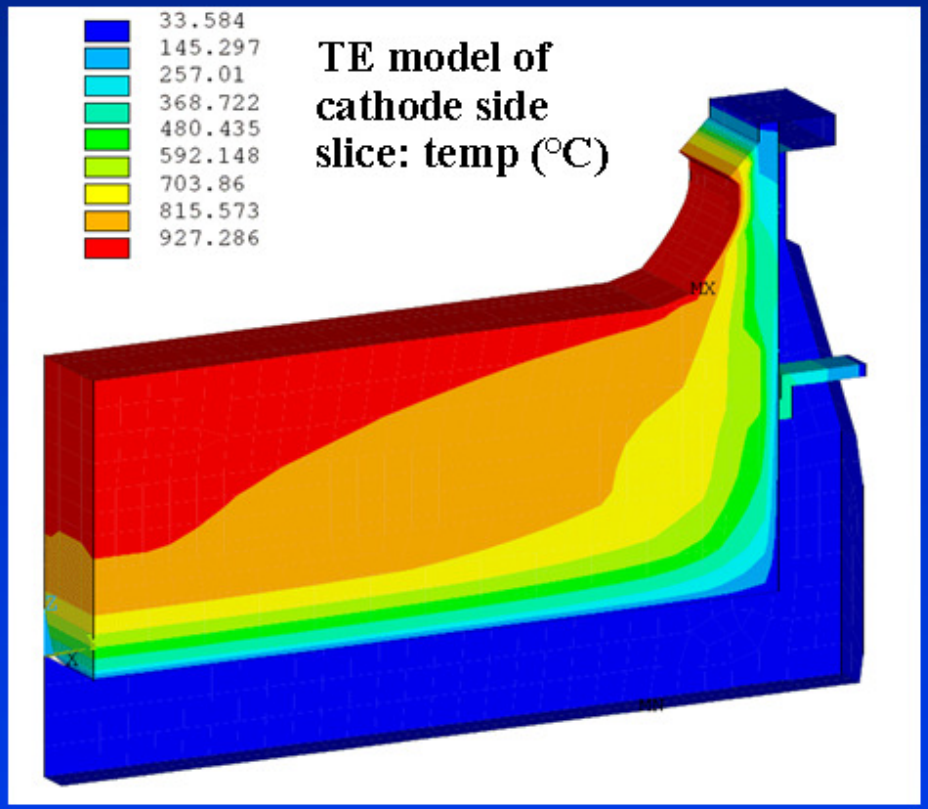
TEM model of new collector bar slot design



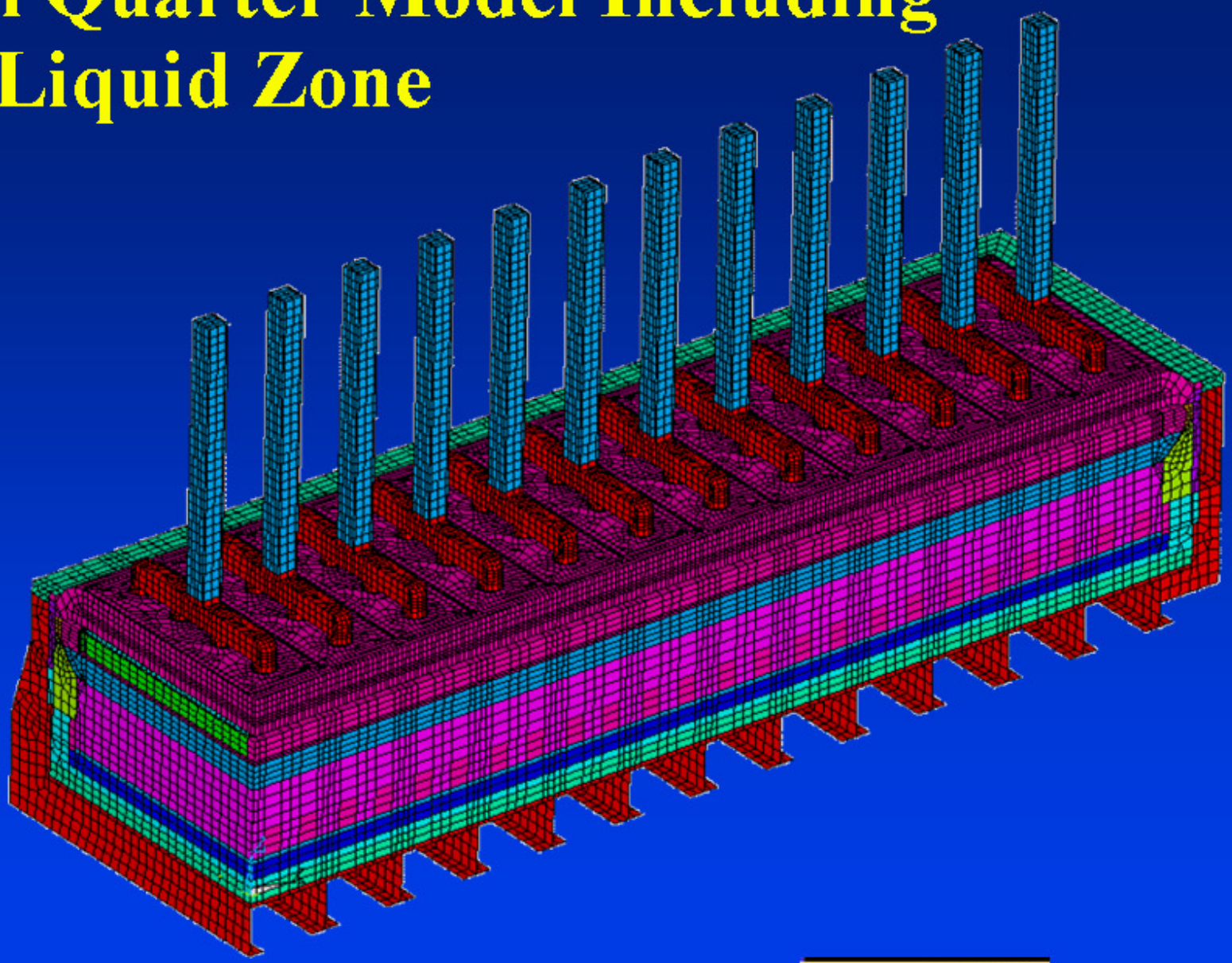

Cathode voltage drop (V)

# New Cathode Collector Bar Slot TEM Model and Cathode Design



# Full Cell Quarter Model Including the Liquid Zone



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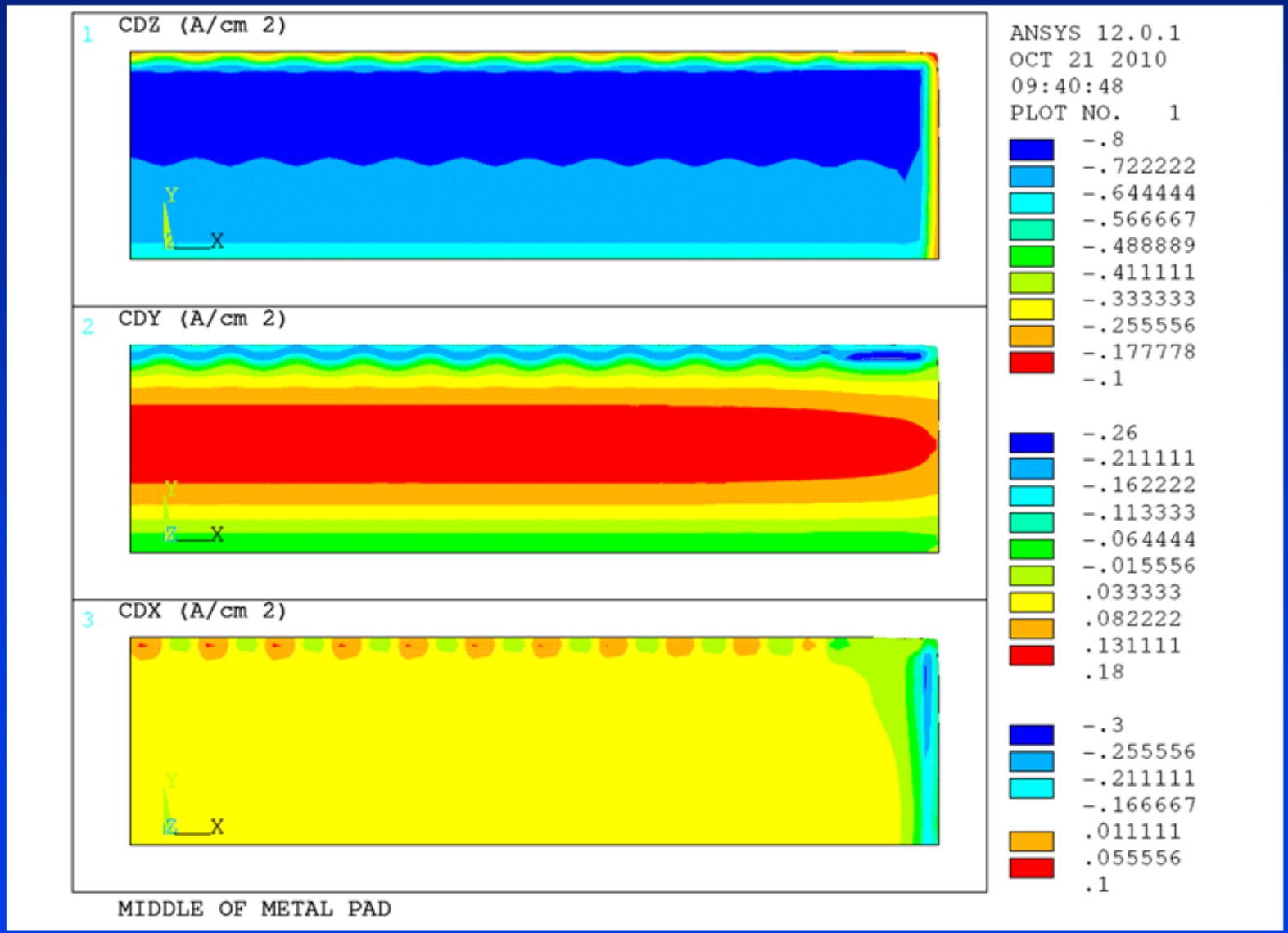

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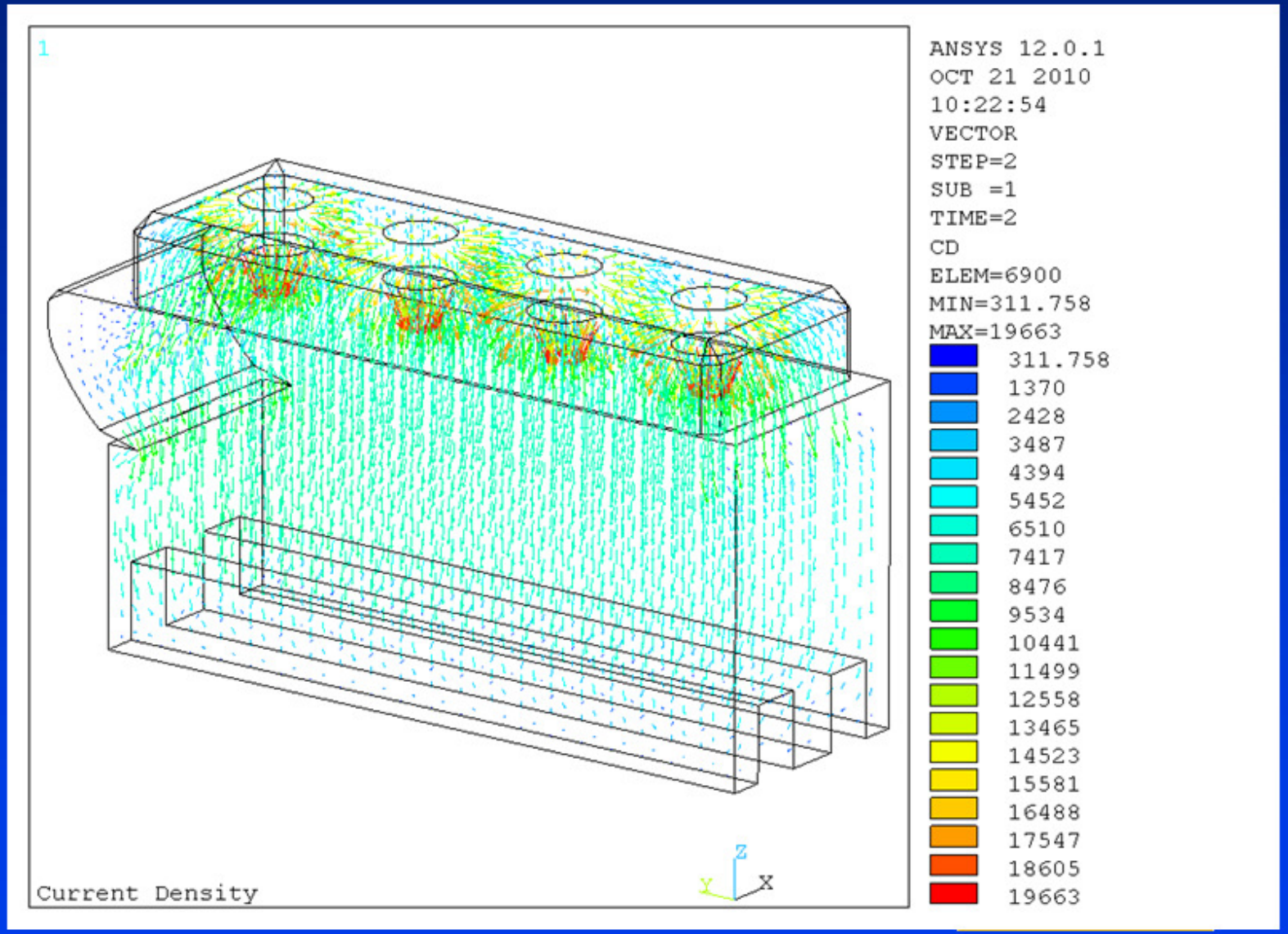
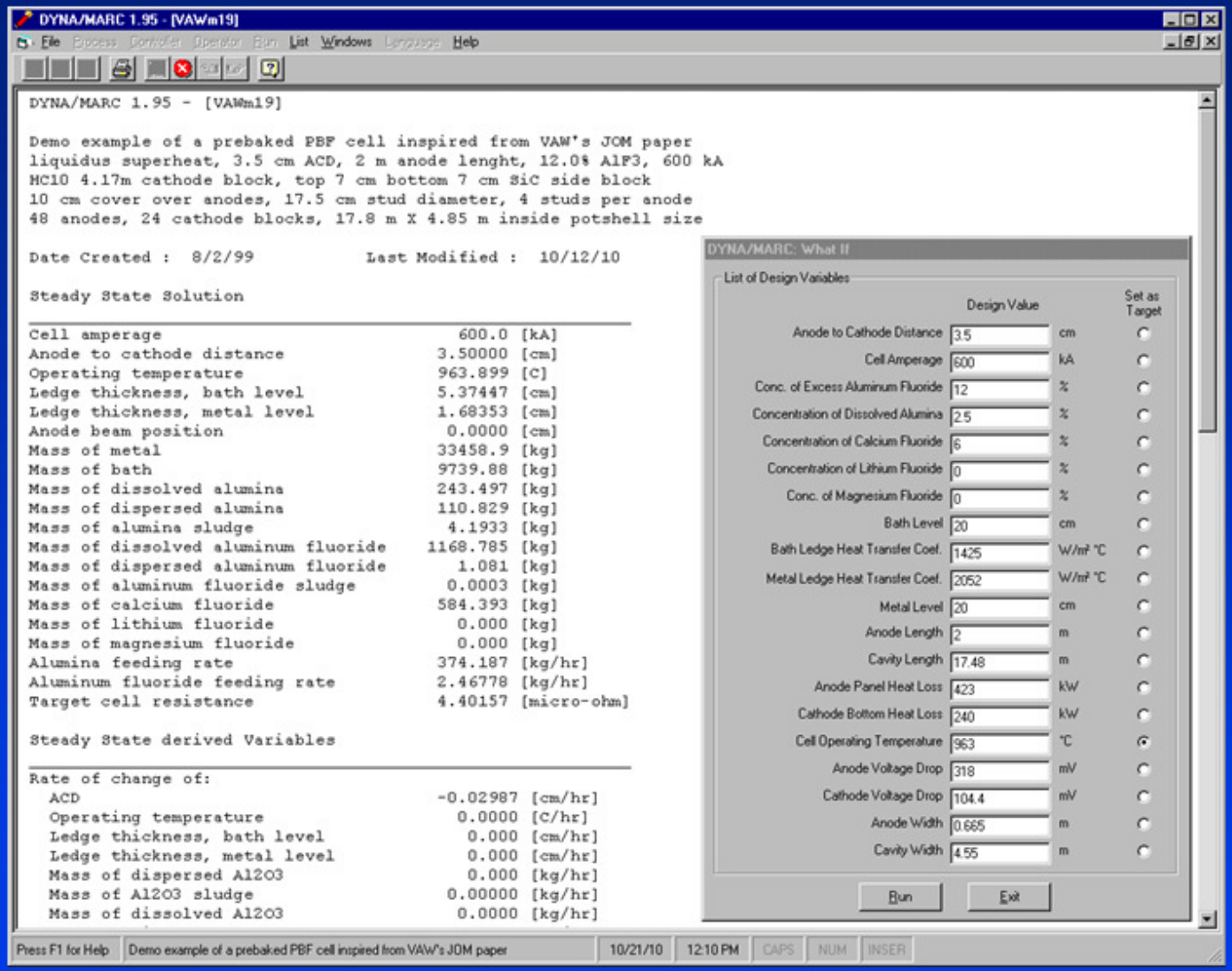


# Retrofitted 600 kA Cell Design




| | |
|---|---|
| Amperage | 600 kA |
| Nb. of anodes | 48 |
| Anode size | 2.00 m X 0.665 m |
| Nb. of anode studs | 4 per anode |
| Anode stud diameter | 17.5 cm |
| Anode cover thickness | 10 cm |
| Nb. of cathode blocks | 24 |
| Cathode block length | 4.17 m |
| Type of cathode block | HC10 |
| Type of side block | SiC |
| Side block thickness | 7 cm |
| ASD | 28 cm |
| Inside potshell size | 17.8 X 4.85 m |
| ACD | 3.5 cm |
| Excess $AlF_3$ | 12.0 % |
| Anode drop | 318 mV |
| Cathode drop | 104 mV |
| Anode panel heat loss | 423 kW |
| Cathode bottom heat loss | 240 kW |
| Operating temperature | 963.9 °C |
| Liquidus superheat | 11.8 °C |
| Bath ledge thickness | 5.37 cm |
| Metal ledge thickness | 1.68 cm |
| Current efficiency | 96.4 % |
| Internal heat | 1141 kW |
| Energy consumption | 13.26 kWh/kg |

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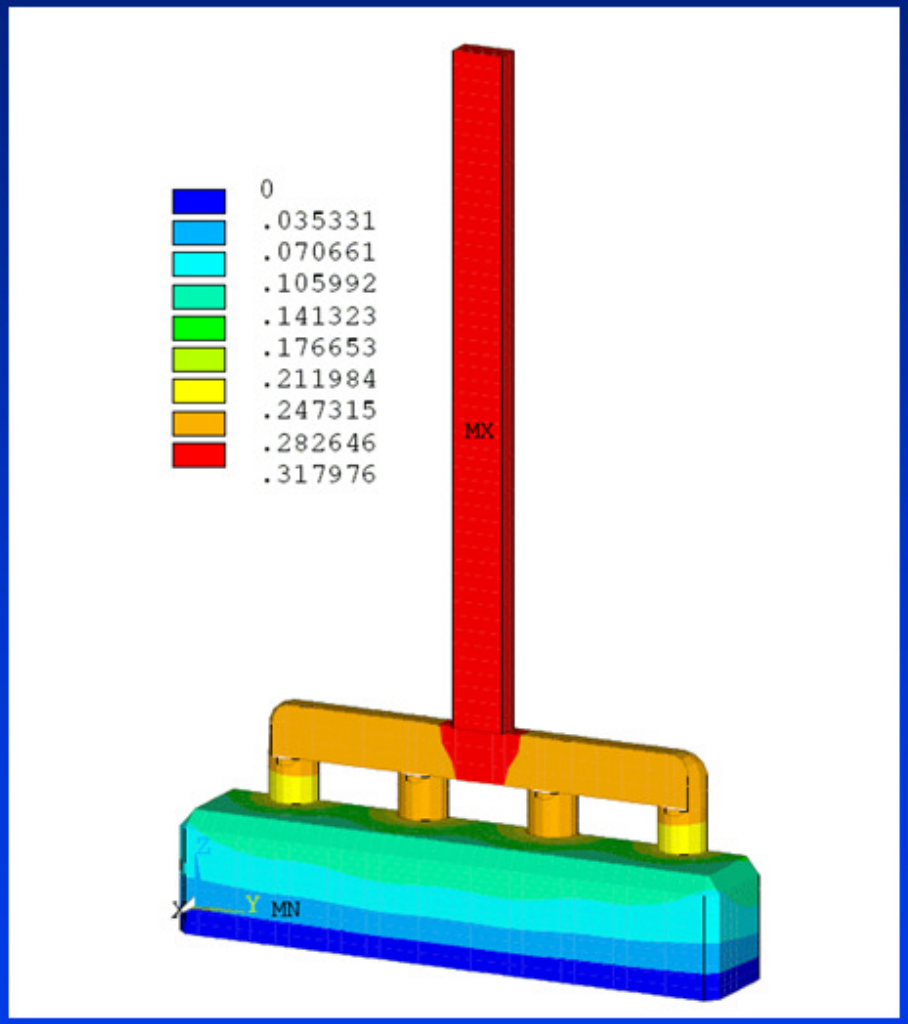
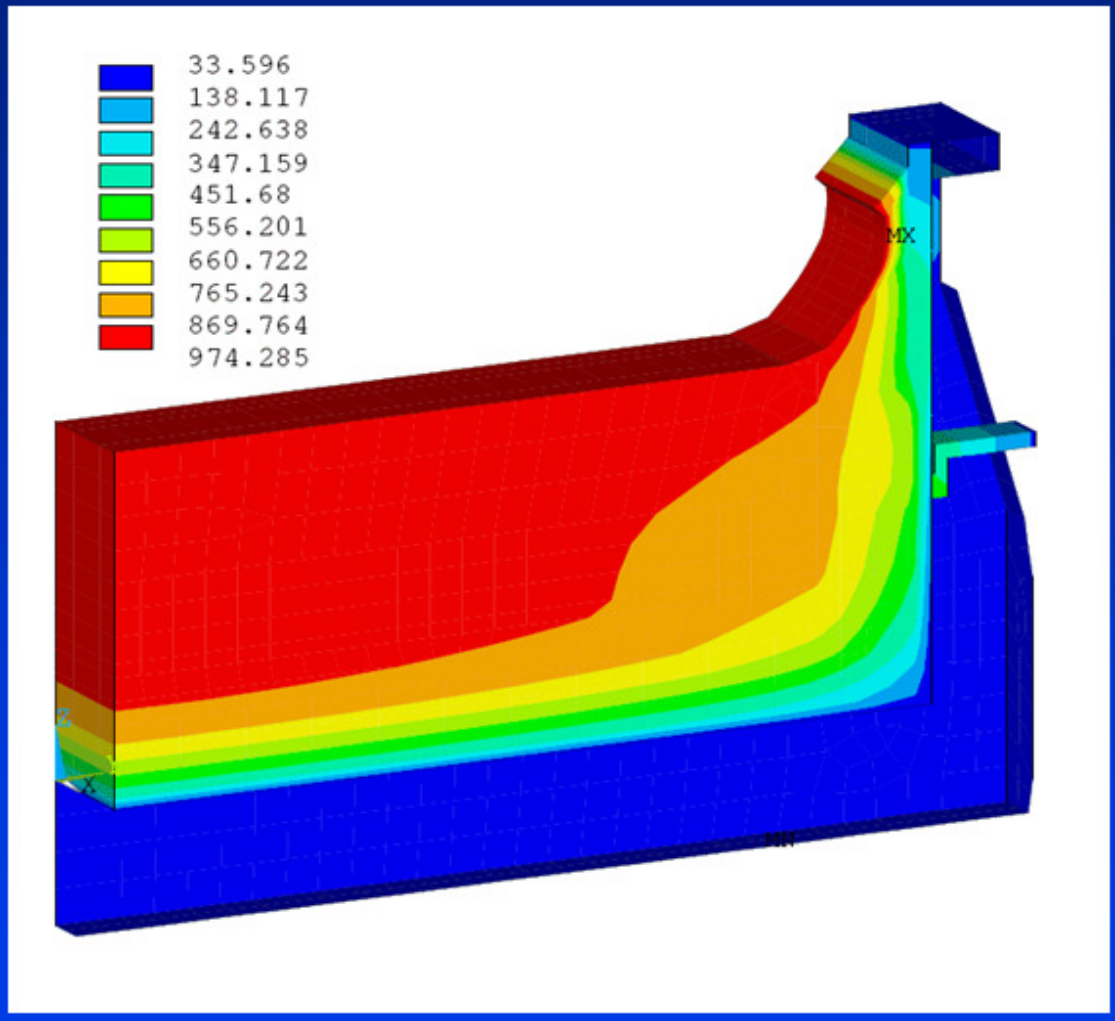
# Verification of the Thermal Balance at 600 kA Using the ANSYS® based TE Models

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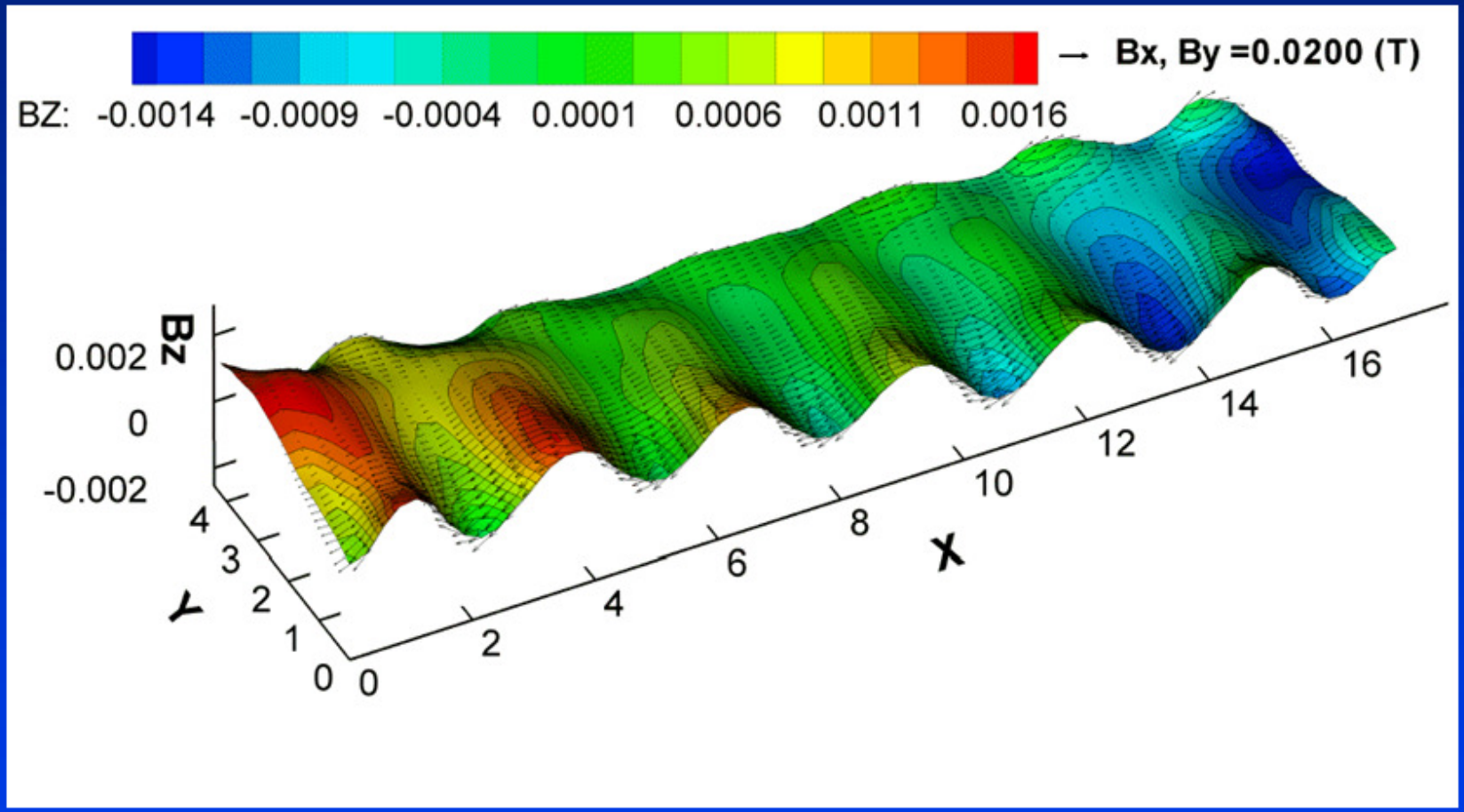
# Verification of the MHD Stability at 600 kA

Design no 3:

Alternative compensation busbar



# Verification of the MHD Stability at 600 kA

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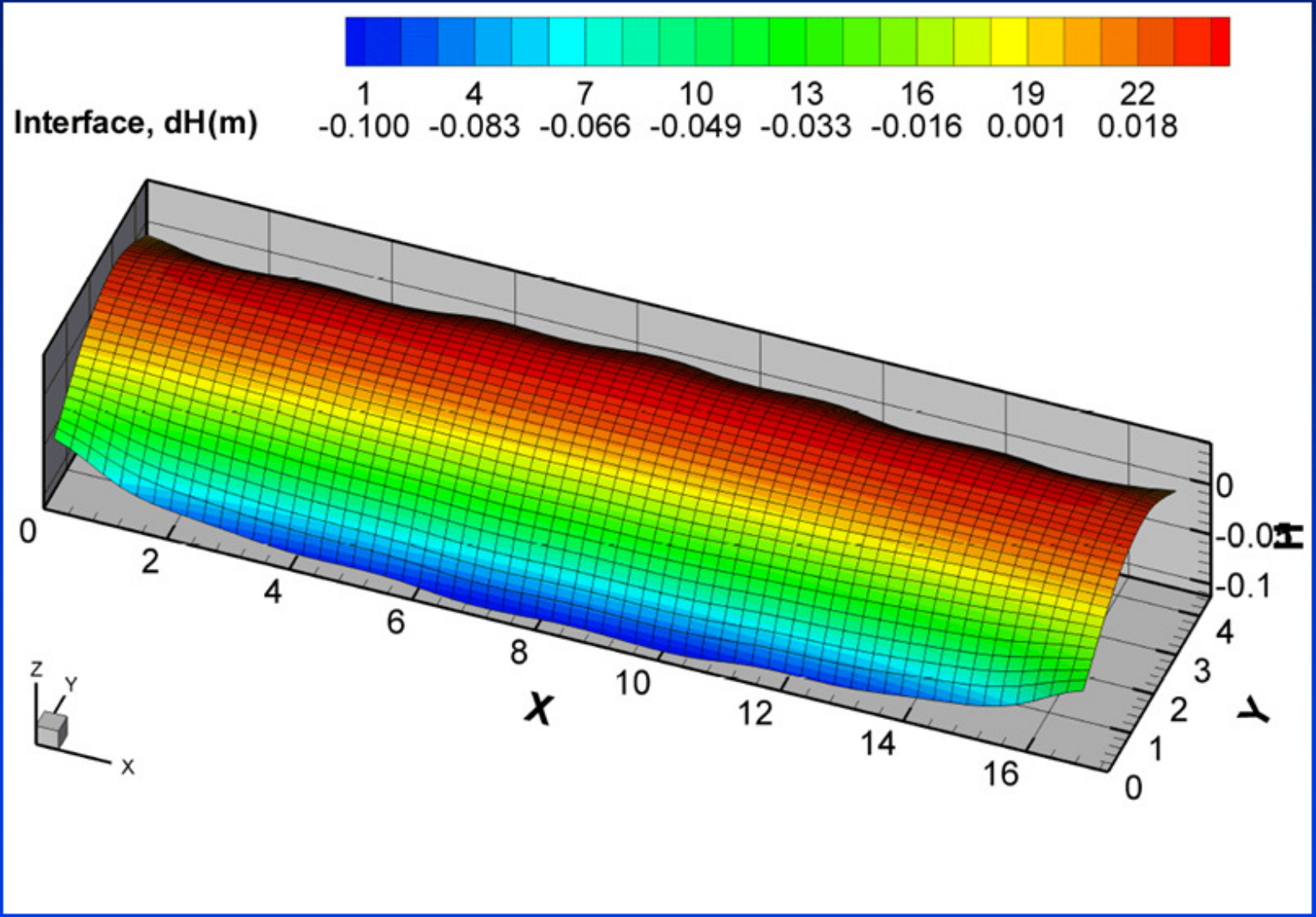


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# Verification of the MHD Stability at 600 kA

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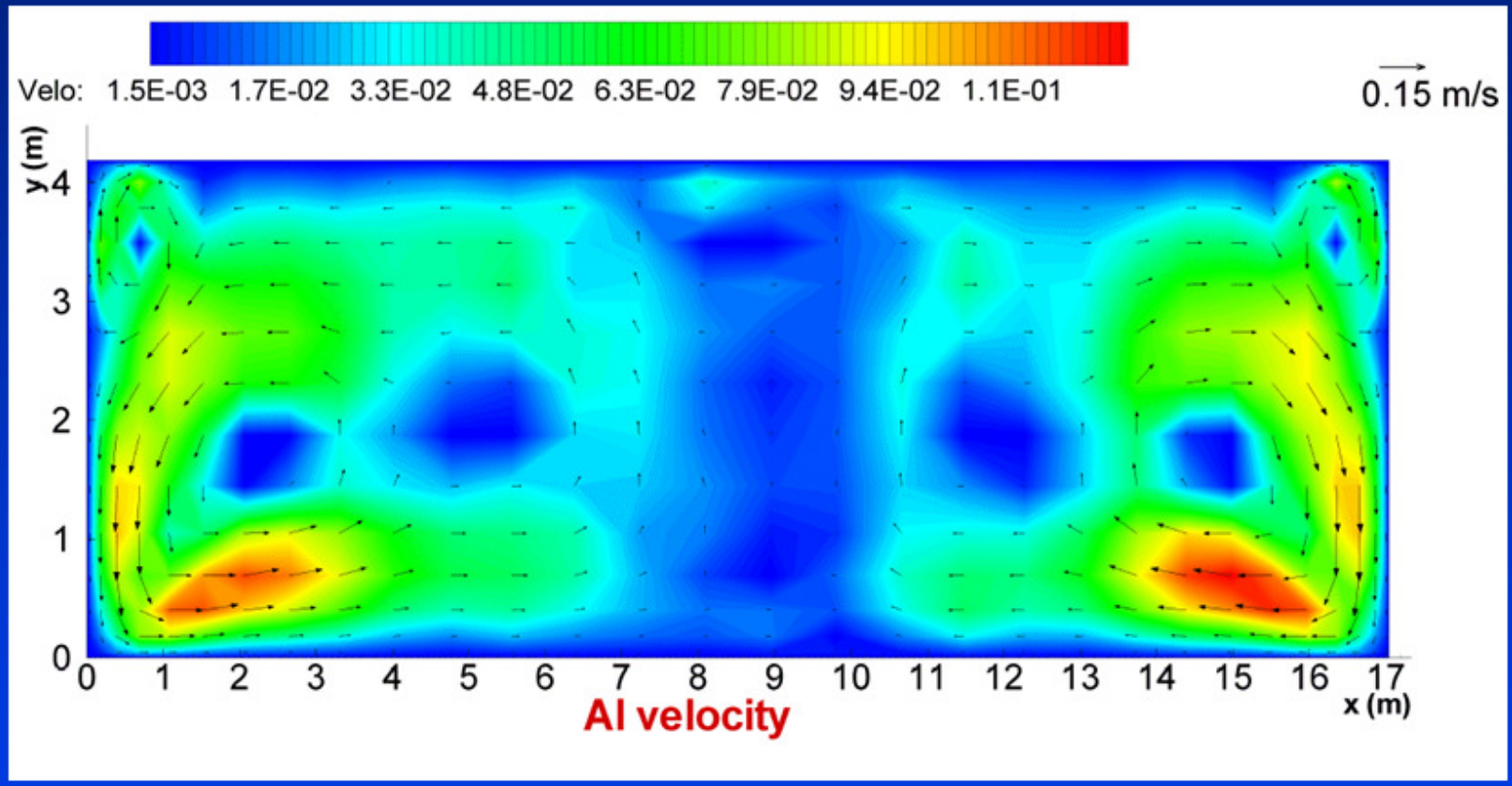

# Verification of the MHD Stability at 600 kA

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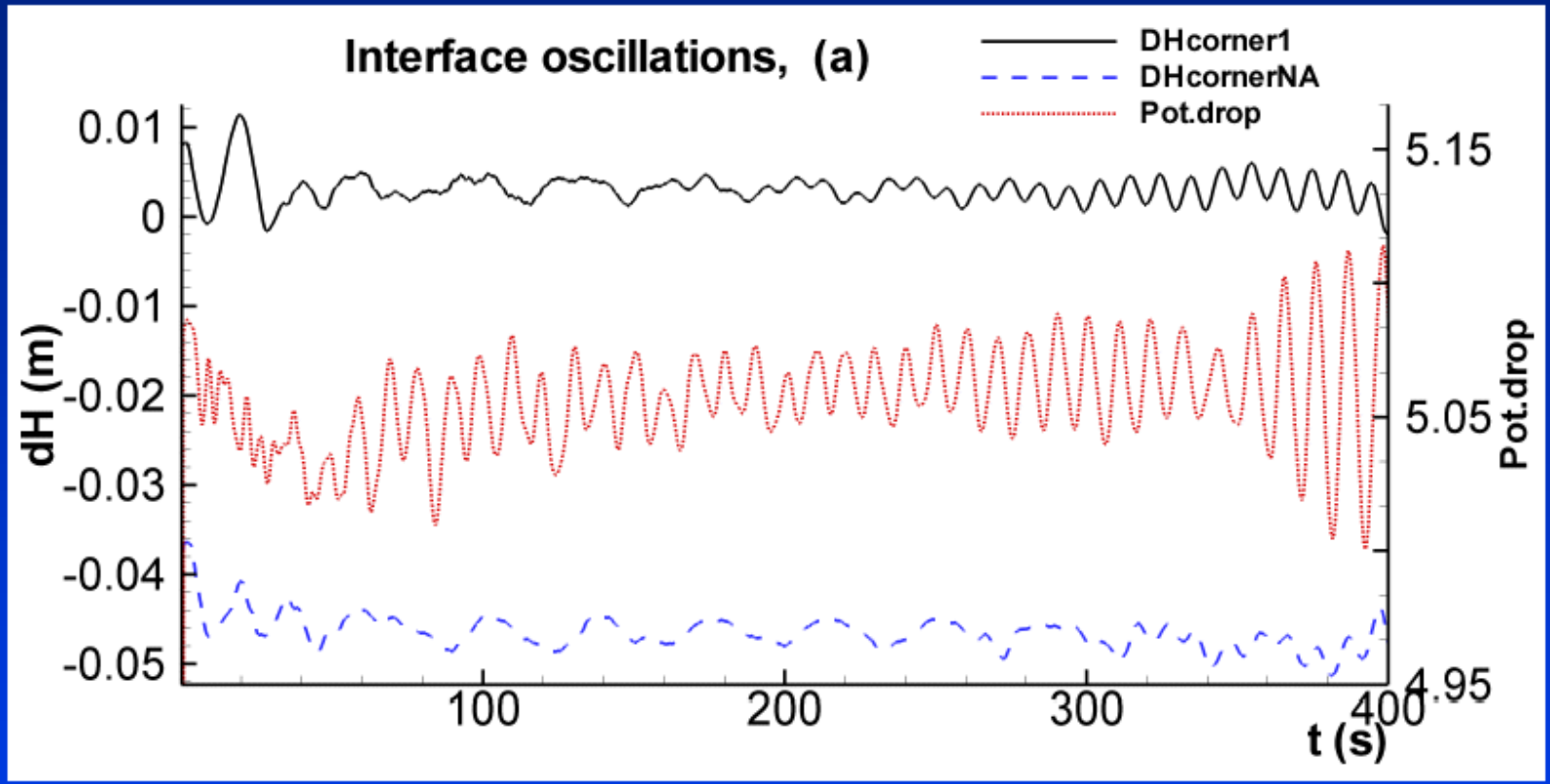

# Conclusions

- This demonstration retrofit study of a 10 years old "past prime if not obsolete" 500 kA cell technology into an up-to-date "innovative" 600 kA cell technology highlights the huge capacity creep potential that is present in even fairly recent cell designs.
- The authors also hope that this demonstration study highlights the value of using mature state of the art mathematical models to carry-up such studies.
- Those models, used by the majority of the groups actively developing high amperage cell technology today, are available to the whole aluminium industry through GeniSim Inc.

# GENISIM

## Clients list:

### 3D ANSYS® T/E models

Alcan
Alumax
Reynolds
Hoogovens
Alcoa
Noranda
Indal
Nalco
SAMI
Comalco
NEUI
Dubal
GAMI

### MHD-Valdis

SAMI
NEUI
Dubal
GAMI
Rusal

### Dyna/Marc cell simulator

Alcan
Alusuisse
VAW
Alumax
Reynolds
Hoogovens
Hydro Aluminium

# GENISIM

## Dr. Marc Dupuis Experience Building
## T/E Models

**With Alcan**
**1984-1994:**

- Alcan prototypes: A275, A265-H, A310
- Alcan prebaked: A70, A140, A165
- Alcan HSS
- Alcoa P155
- Pechiney AP18

**With GeniSim**
**1995-2011:**

- Pechiney AP18, AP30
- Alcoa: P155, A697
- Reynolds prebaked: P-19, P-20S, P-23S
- Kaiser P69
- SAMI 300 kA
- NEUI 300 kA
- GAMI 300 kA, 420 kA
- Dubal DX, D20
- VAW 240 kA
- Comalco B32
- Reynolds HSS
- Pechiney HSS
- Alcan VSS