Presentation of a New Anode Stub Hole Design Reducing the Voltage Drop of the Connection by 50 mV

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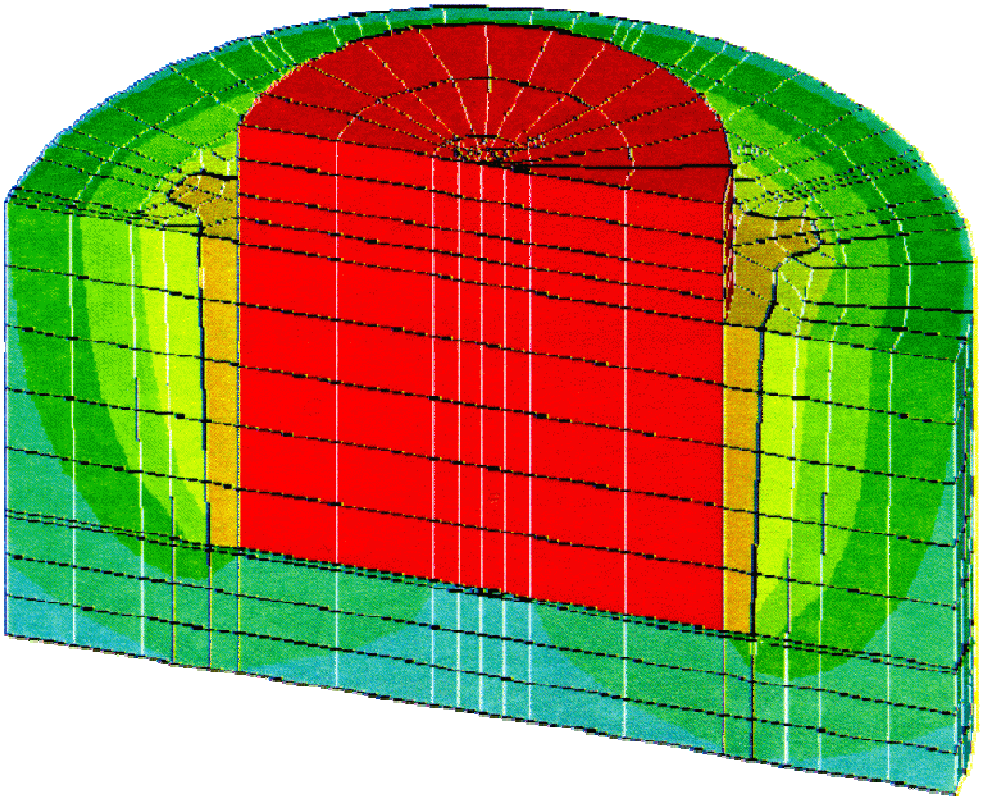
Plan of the Presentation

- Introduction
- New stub hole design strategy
- Test of new stub hole designs using the TEM model
- Conclusions

Introduction

The voltage drop at the anode cast iron-carbon interface is about 30% of the total anode voltage drop



Ref: D. Richard, “Conception des tourillons d’anode en usage dans une cuve de Hall-Héroult à l’aide de la méthode des éléments finis”, M.Sc. Thesis, Université Laval, Québec, Canada, (2000).

Introduction

That interface contact resistance can be measured and measurements show that it varies a lot from anode stub hole design to anode stub hole design

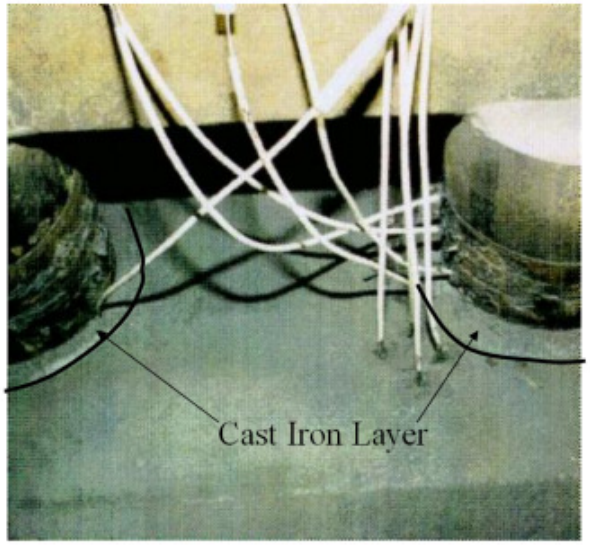


Figure 10 Instrumented anode set-up

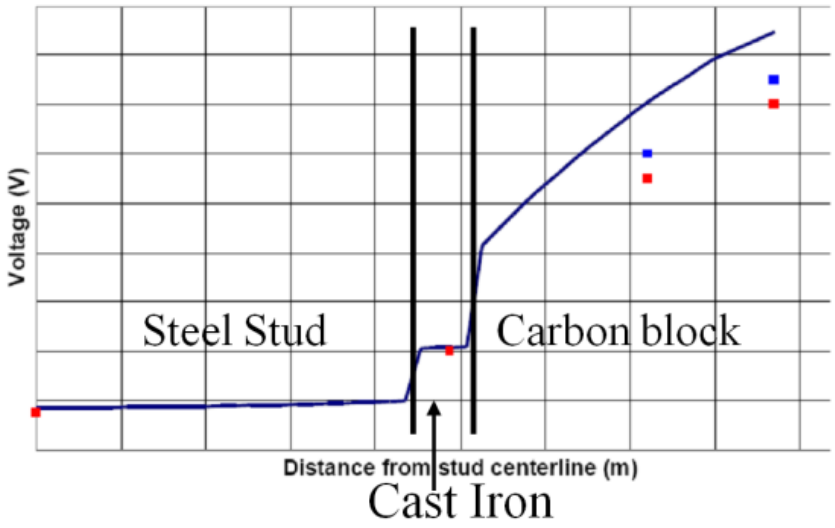


Figure 11 Anode stud voltage drop results

Ref: M. Dupuis and C. Fradet, "Using ANSYS based aluminium reduction cell energy balance models to assist efforts to increase Lauralco's smelter productivity", ANSYS 8th Int. Conf., Vol. 2, (1998), 2.233-2.240.

Introduction

Observed variations in contact resistance are linked to the measured fact that this contact resistance is pressure and temperature dependent

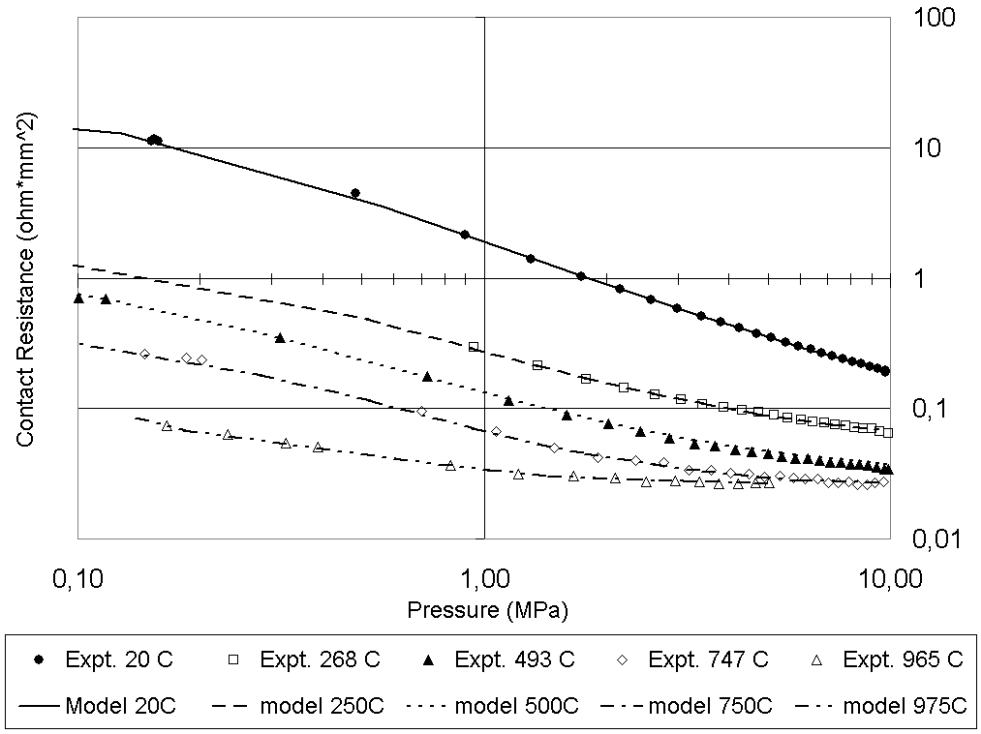
$$R_c = A(T) - B(T)exp\left(\left(\frac{P}{C(T)}\right)^{D(T)}\right)$$

$$A(T) = exp\left(\frac{a_0 + a_1 T}{1 + a_2 T + a_3 T^2}\right)$$

$$B(T) = exp\left(\frac{b_0 + b_1 T}{1 + b_2 T + b_3 T^2}\right)$$

$$C(T) = c_0 + c_1 T$$

$$D(T) = d_0 + d_1 T$$



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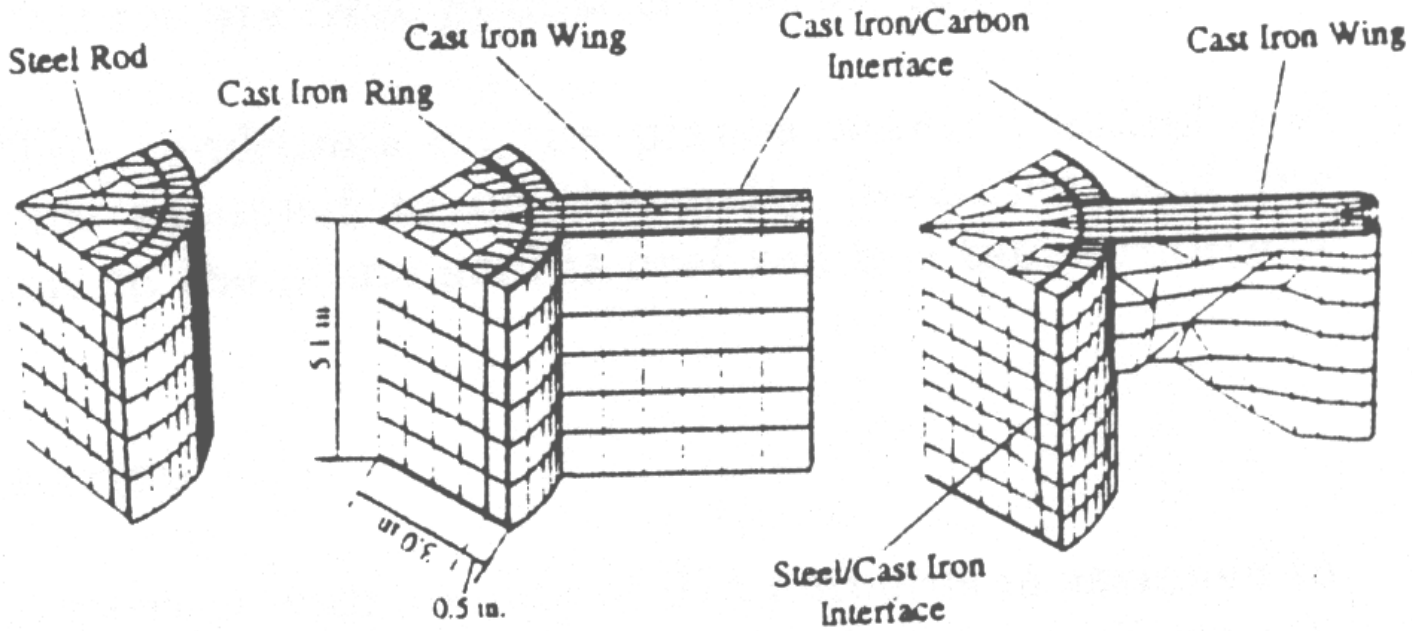
Introduction

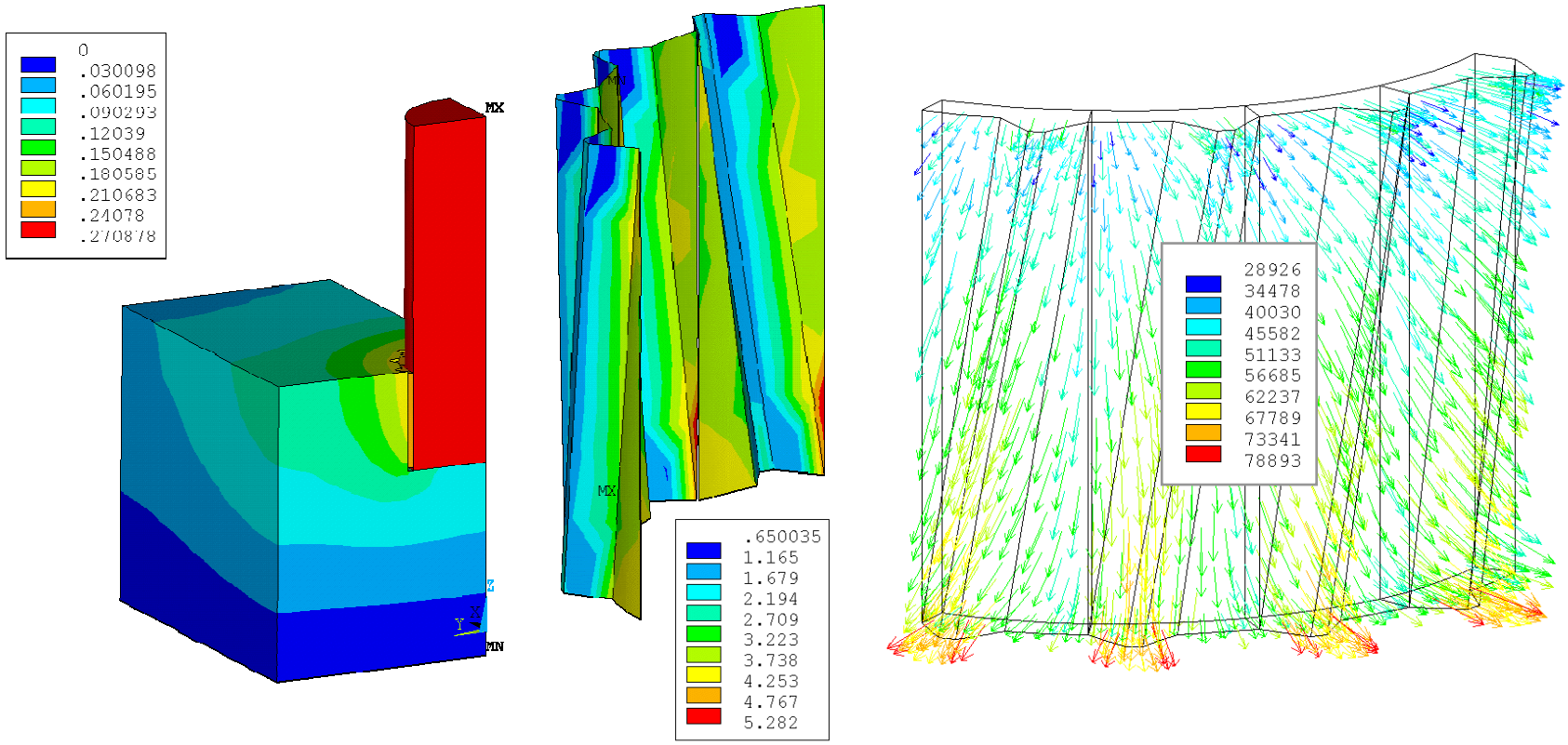
This explains why stub hole designs neglecting to account for the pressure dependency are not working



Ref: T.X. Hou, Q. Jiao, E. Chin, W. Crowell and C. Celik, "A numerical model for improving anode stub design in aluminum smelting process", Light Metals, TMS, (1995), 755-761.

Introduction

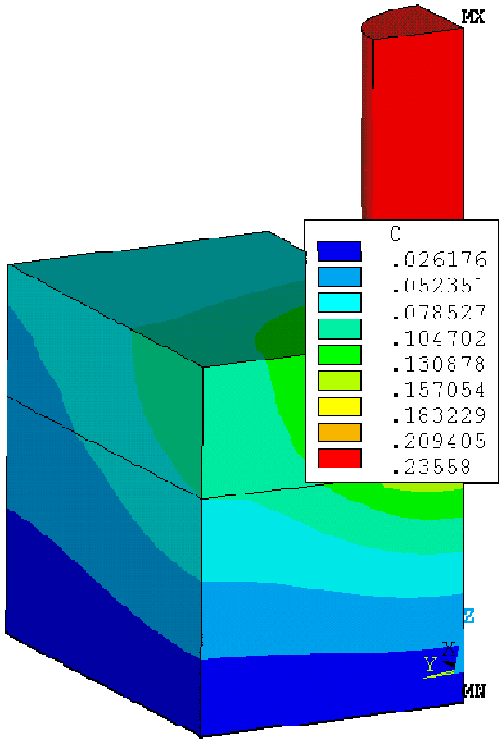
Now fortunately Thermo-Electro-Mechanical (TEM) models have been developed that well represent that dependency

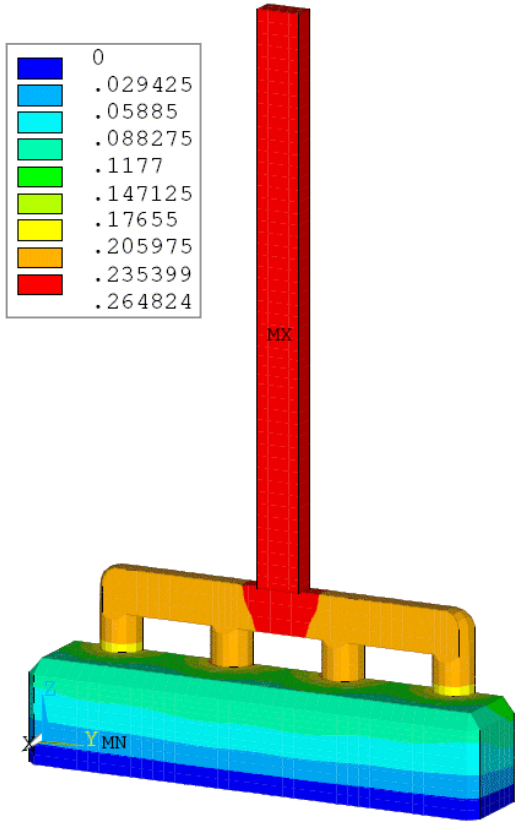


Ref: M. Dupuis, Development and application of an ANSYS based thermo-electro-mechanical collector bar slot design tool, Light Metals, TMS, (2010), 433-438.

Introduction

In 2011, that TEM model has been used to design a new type of stub hole aiming at reducing the anode voltage drop





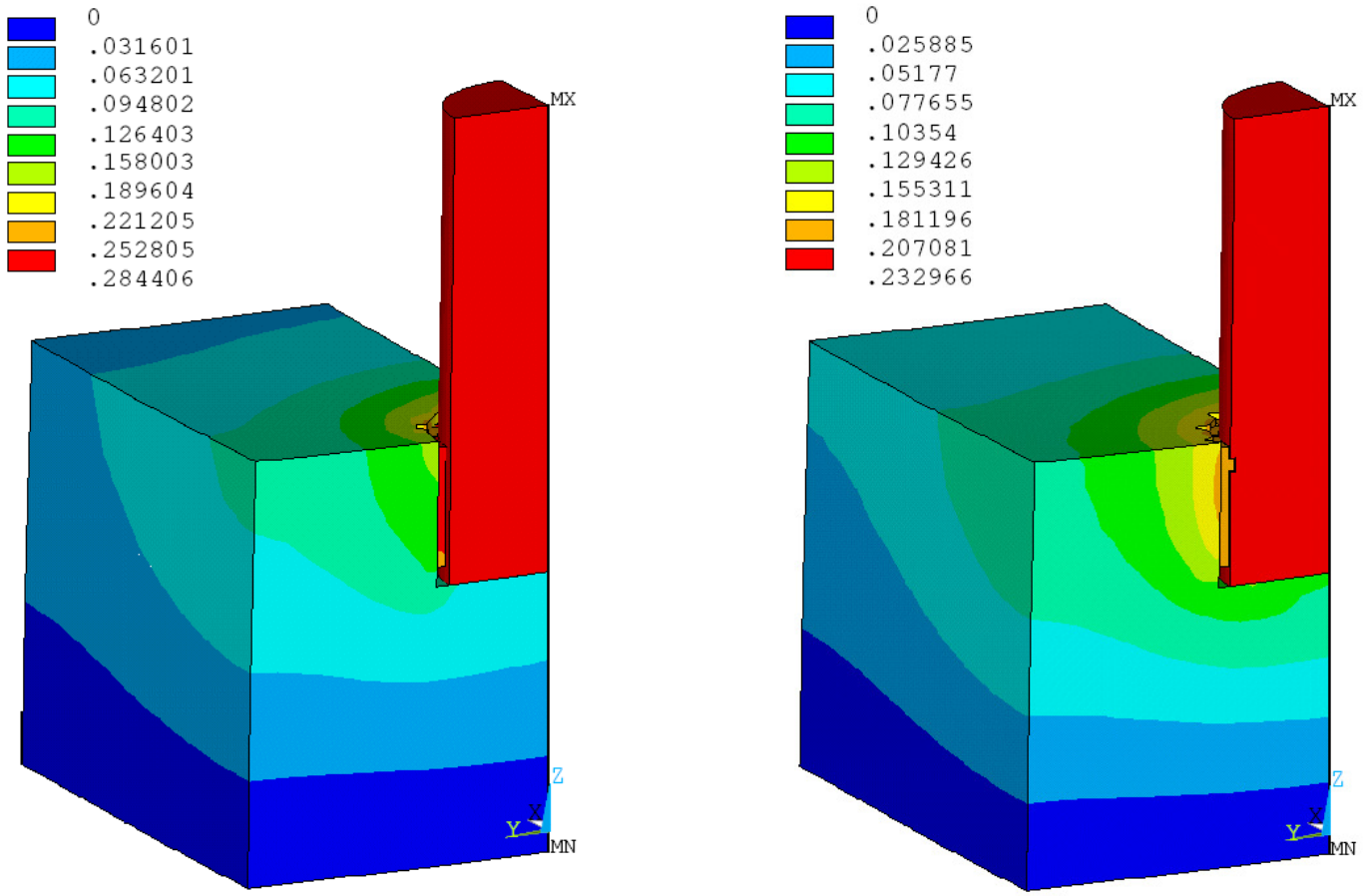
Ref: M. Dupuis and V. Bojarevics, Retrofit of a 500 kA cell design into a 600 kA cell design, ALUMINIUM 87(1/2), 2011, 52-55.

New stub hole design strategy

- No current is flowing between the bottom of the stub and the base of the carbon stub hole because no contact pressure is developing at that interface.
- Radially, the pressure develops because the steel stub expands more than the carbon block.
- The stub also expands vertically but nothing is preventing it to move up while it expands.
- In order to get contact pressure there too, the stub needs to be prevented to be free to move up while it expands vertically.

Standard stub hole

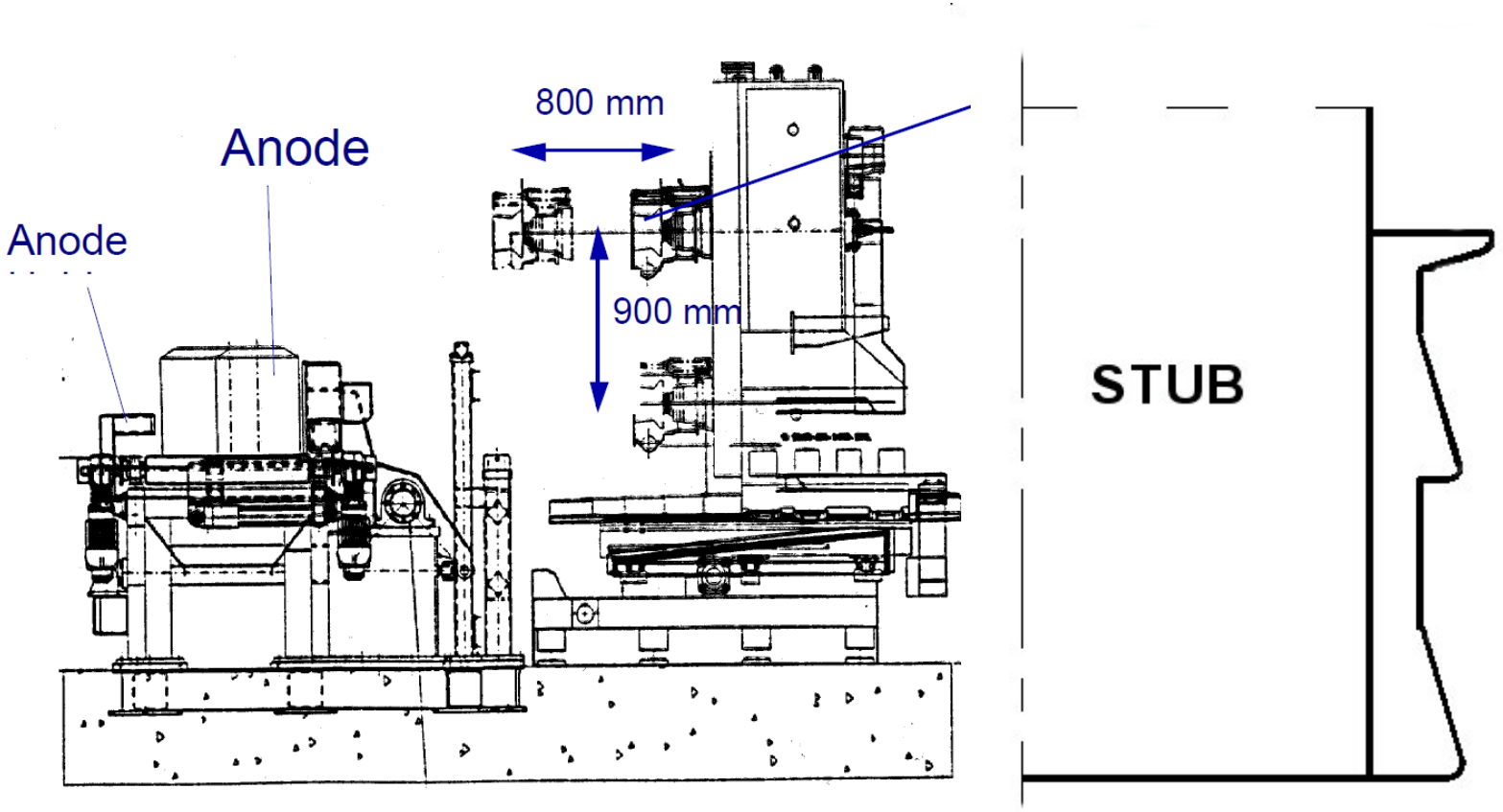
Standard stub hole with a locking key in the stub



With and without locking key in the stub

Drilled (or machined) stub hole

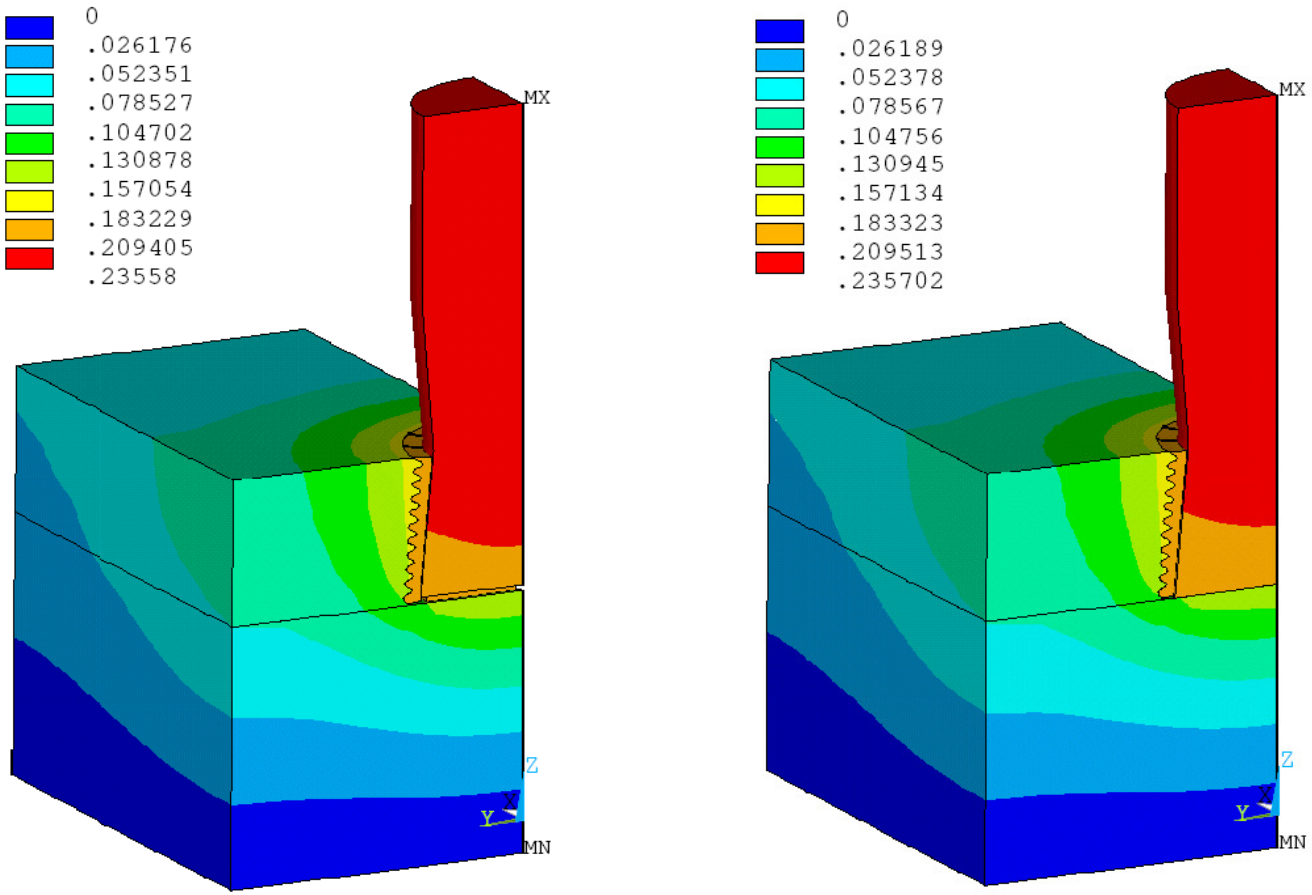
In 2003, a drilled stub hole design was presented



Ref: B. E. Aga, I Holden, H. Linga and K. Solbu, “Drilling of Stub Holes in Prebake Anodes”, Light Metals, TMS, (2003), 541-545.

Drilled (or machined) stub hole

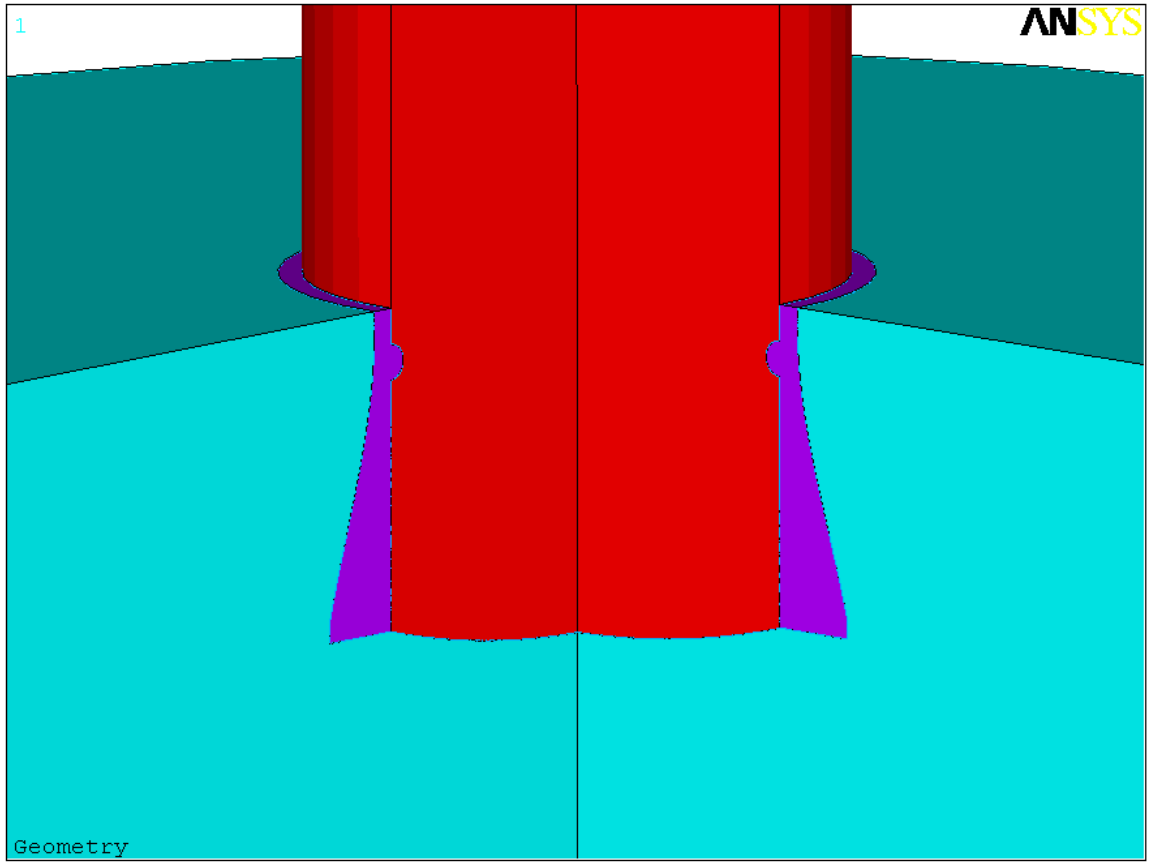
A drilled stub hole design can also be used to vertically lock the stub



With and without cast iron under the stub

Optimized drilled stub hole shape with stub lock key

Optimization of the shape using an axisymmetric TEM model



Optimized drilled stub hole shape with stub lock key

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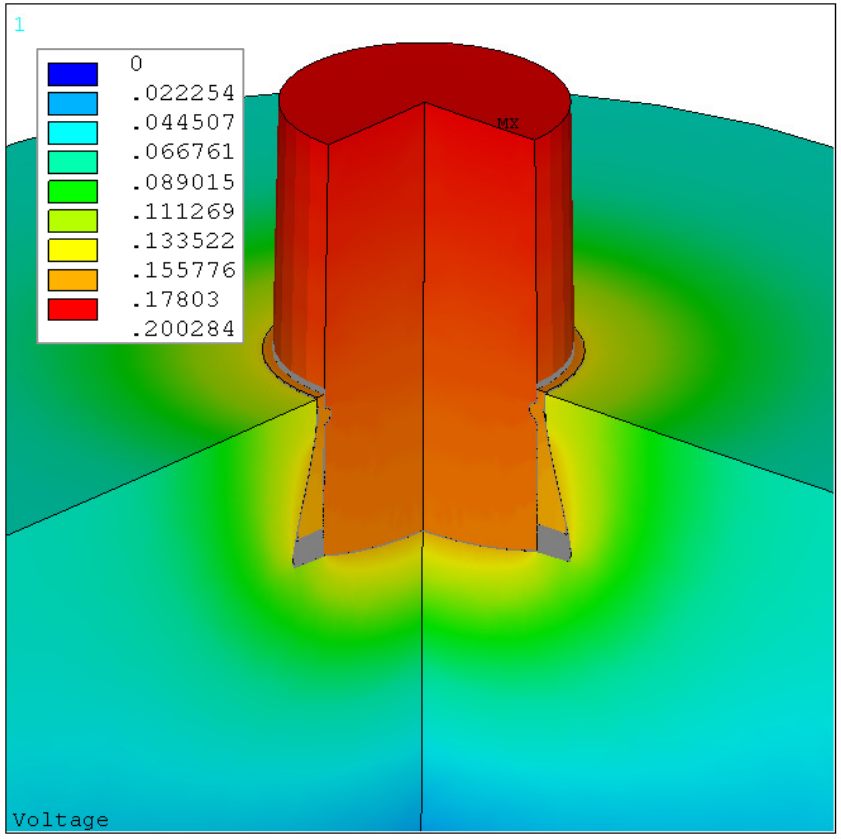

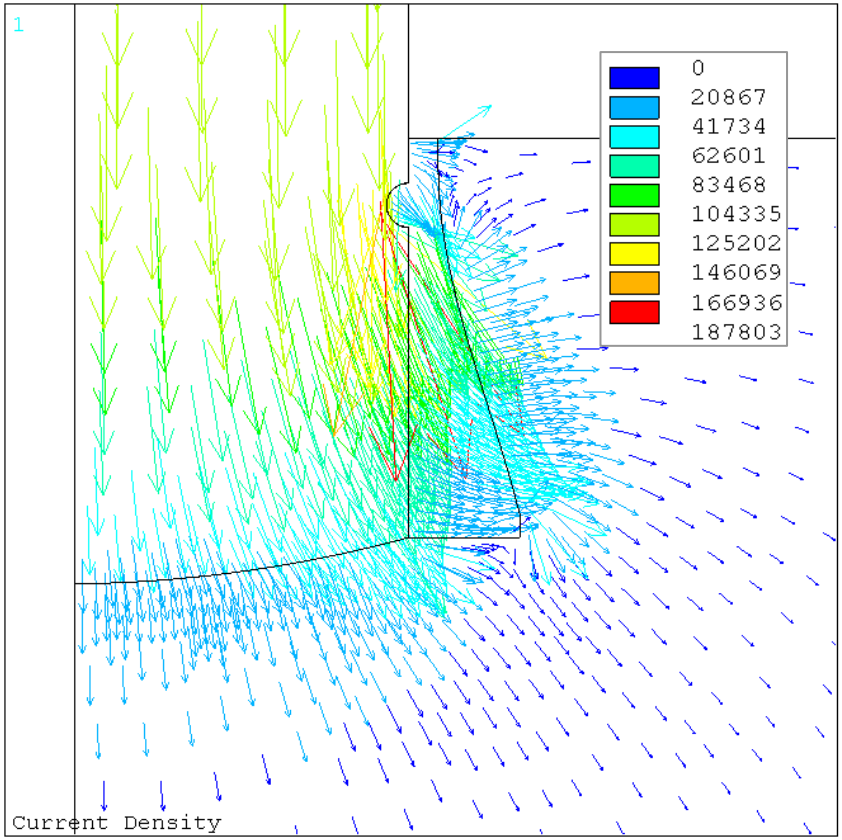

Conclusions

- Richard & Dupuis have developed and patented a new concept of forcing contact pressure on the bottom of the stub.
- 50 mV savings for a 360 ktpa smelter is 2.9 MUSD for 50 USD/MWh cost of energy (high energy cost).
- The next test is to demonstrate mV savings on experimental test rig.