Anode to Cathode Electrical Current Modelling for Cell Retrofit Application of Conductive Nails Technology

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About the Presenter

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- Former R&D Mgr/Product Mgr for rodshop equipment at AISCO(Outotec).
- Former Director of Smelter Power Reduction Technology Development at Hatch.
- Inventor of Conductive Nails Technology for Anodes & Cathodes.
- Patents CA2914511, CN204385308 + Int’l filings
- www.AluCellTech.com

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How can you easily improve the performance of existing pots, without changing their design?

- By reducing the electrical contact resistance in the cast iron connections of anode and cathode assemblies to improve the current distribution and reduce pot noise.

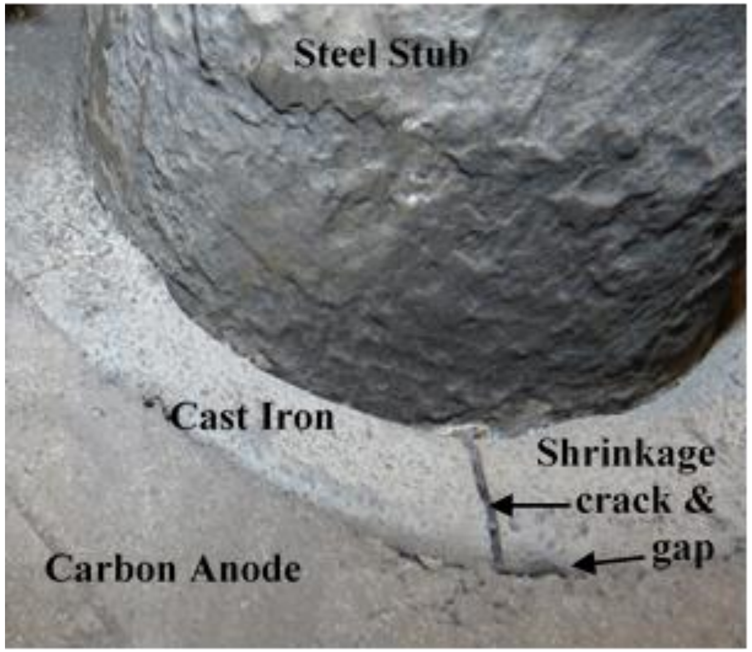
Presentation:

- Potential benefits of improving current distribution.
- Anode Nails, Cathode Nails & Shaped Iron Technology.
- ANSYS modelling of electrical current distribution.
- Potential Economic Benefits & Implementation path of these Technologies.

What are the Potential Benefits of Conductive Nails & Shaped Iron Technology

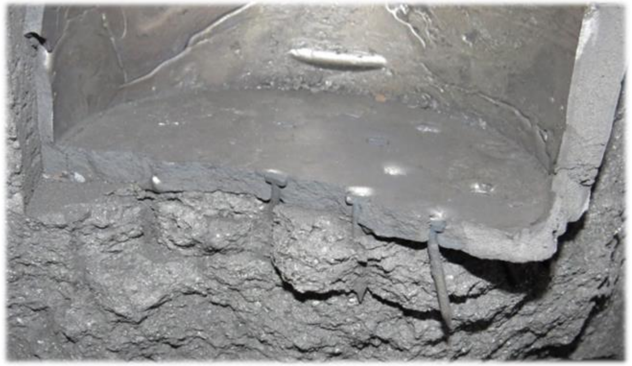
- Reduce Electrical Resistance and Power Consumption
- Reduce Pot Noise to:
  - Increase Current Efficiency
  - Reduce Perfluorocarbon Emissions
  - Enable Higher Amperage & Production
- Reduce the Rate of Cathode Corrosion for Longer Potlife
- Reduce Anode Airburn and Net Carbon Consumption

Anode Nails reduce contact resistance in the Stub to Carbon Iron Connection



>3% Cast iron solidification shrinkage creates an air gap causing high electrical contact resistance, which worsens with stub wear:

- **Resistance heating of anode (promotes airburn)**
- **Uneven current distribution causing potnoise**
- **Nails bridge the air gap to reduce resistance**



Bottom Surface

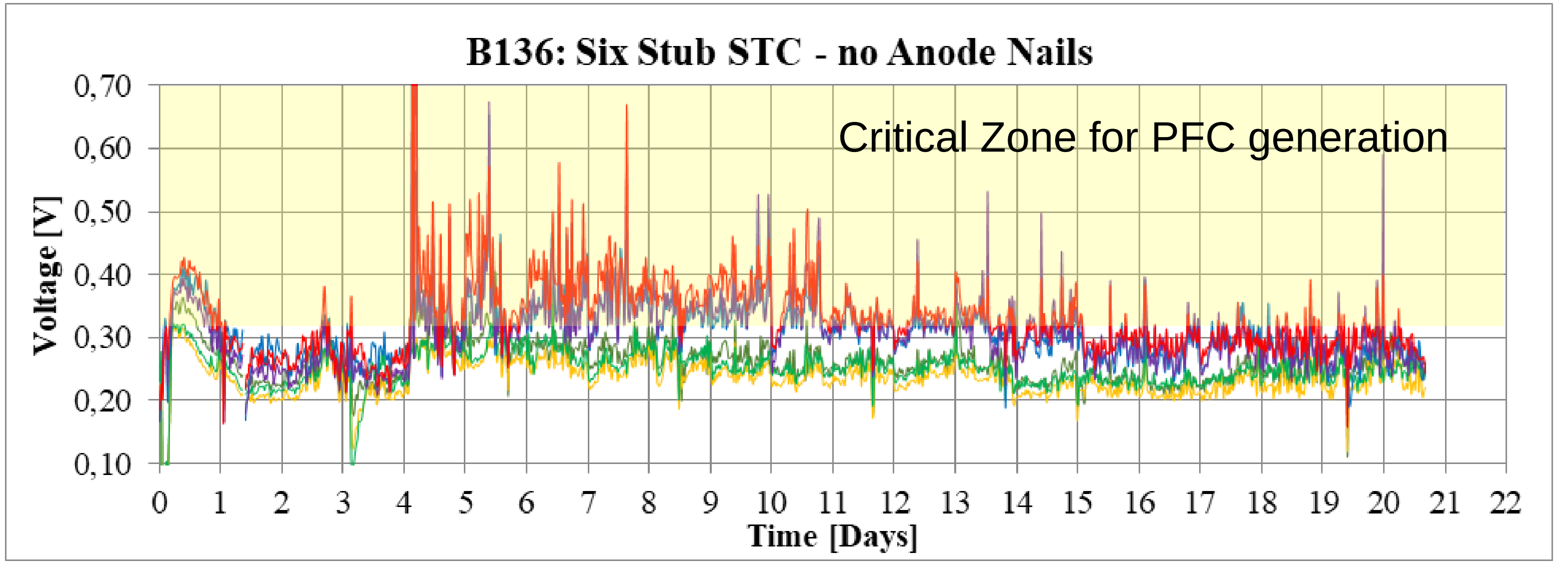
Side walls or grooves

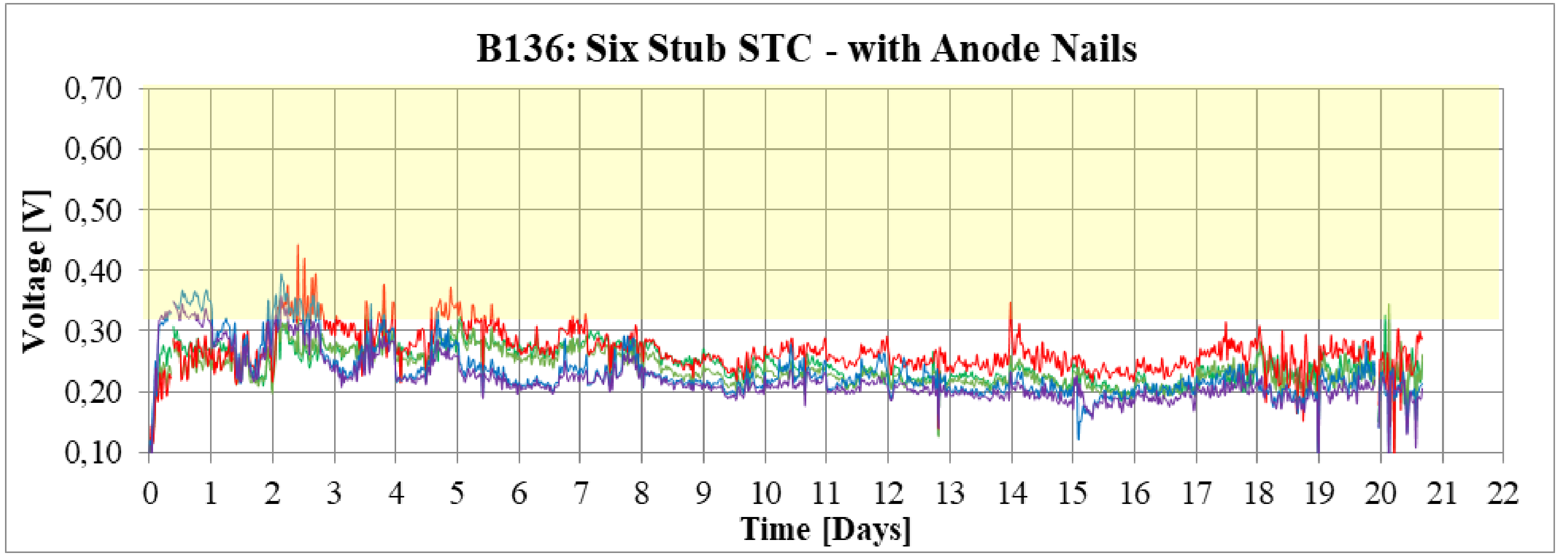
Condition of Anode Nails after Pot Cycle

Nail condition after full anode cycle and anode butt removal

Benefit of Anode Nails on Potnoise

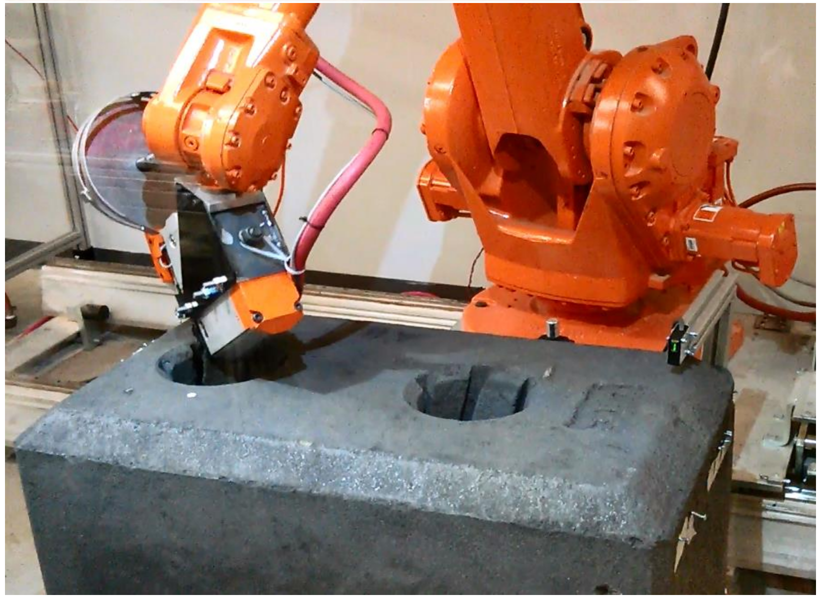
- **Sample of AP30 test of anode pair, without and with Anode Nails.**
- **Average 45 mV savings over anode cycle**
- **~66% reduction in voltage that exceeded 125% of average, critical zone for PFC emissions**



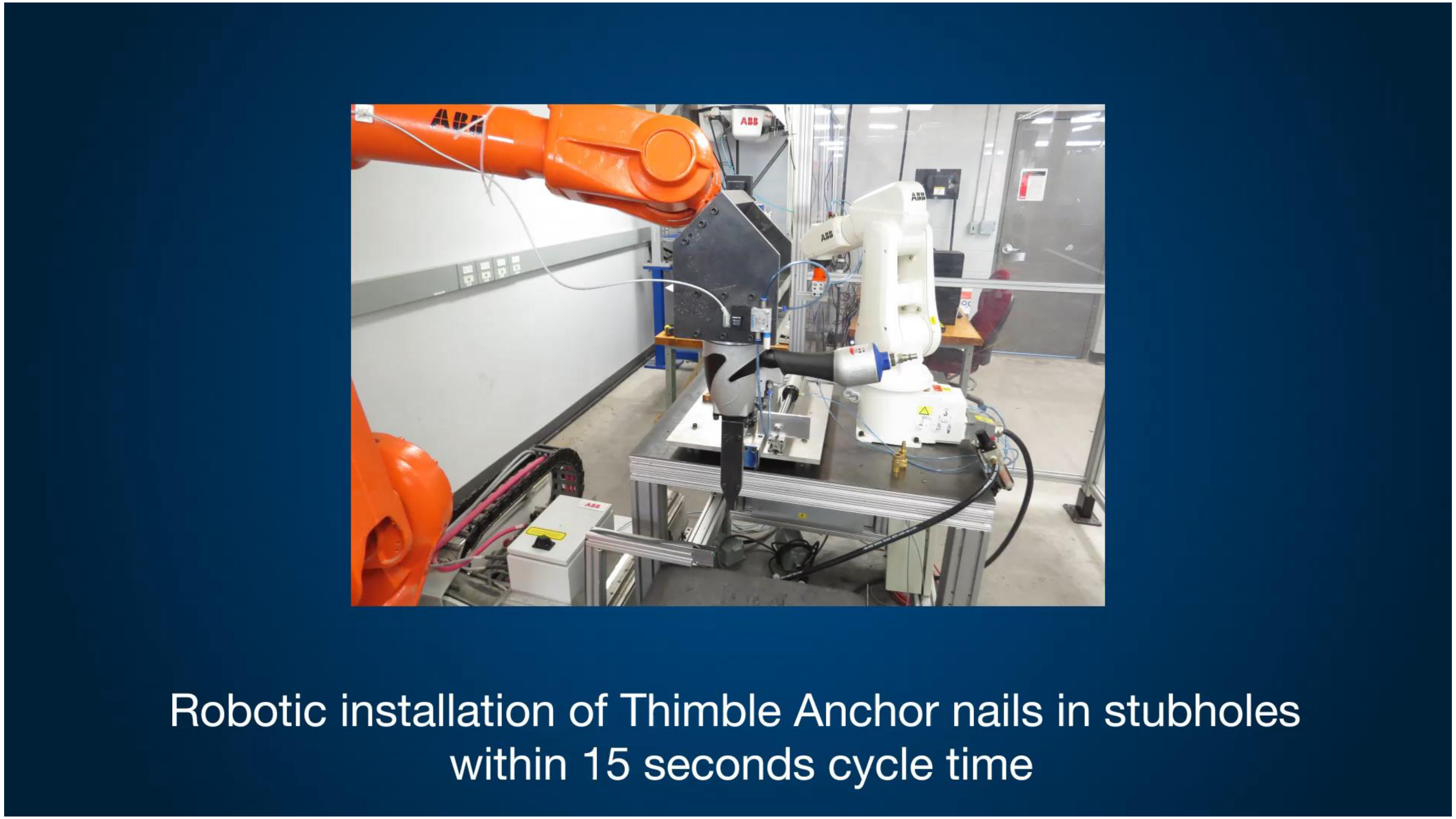


Anode Nails Installation

- **Custom alloy hardened nails, pneumatic nailer**
- **Nailing station in Anode Storage Bay or rodshop, etc., under 60 seconds/anode**
- **Manual station– lowest cost option, opex ~$1.5/ton aluminum produced**
- **Robotic Station**
  - **Fewer operators**
  - **Automatic reloading of nails**
  - **Opex ~$3/ton aluminum produced**

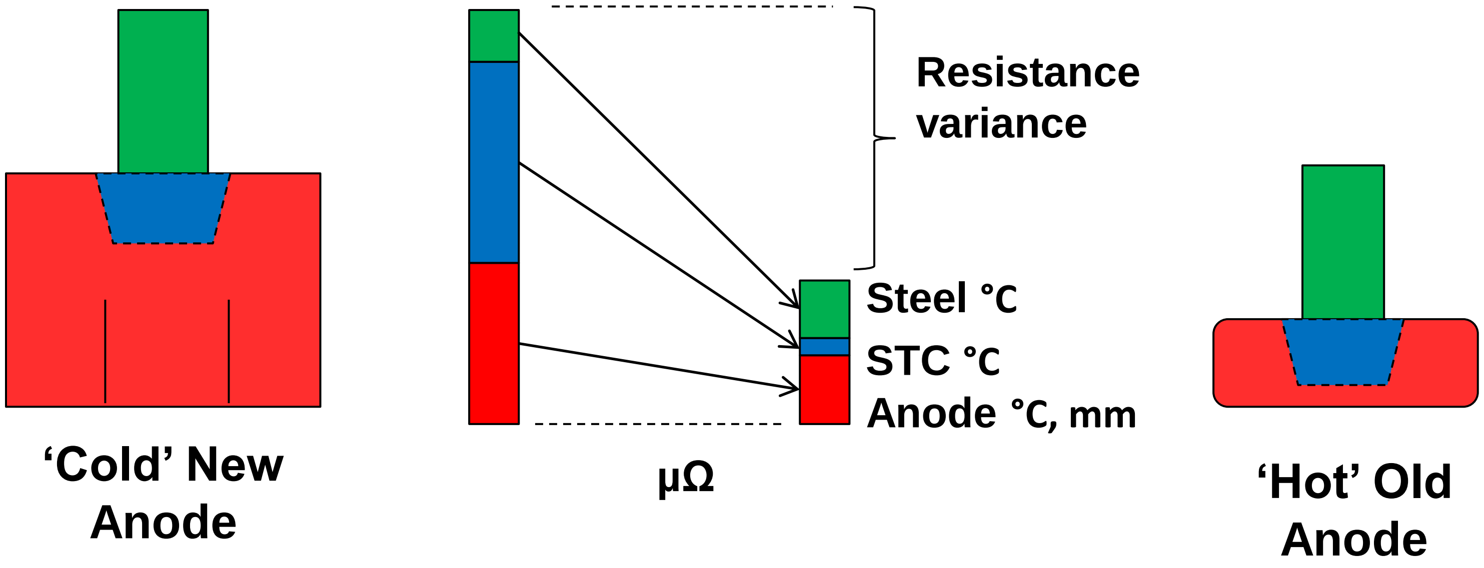


Robotic Nailer with Reload

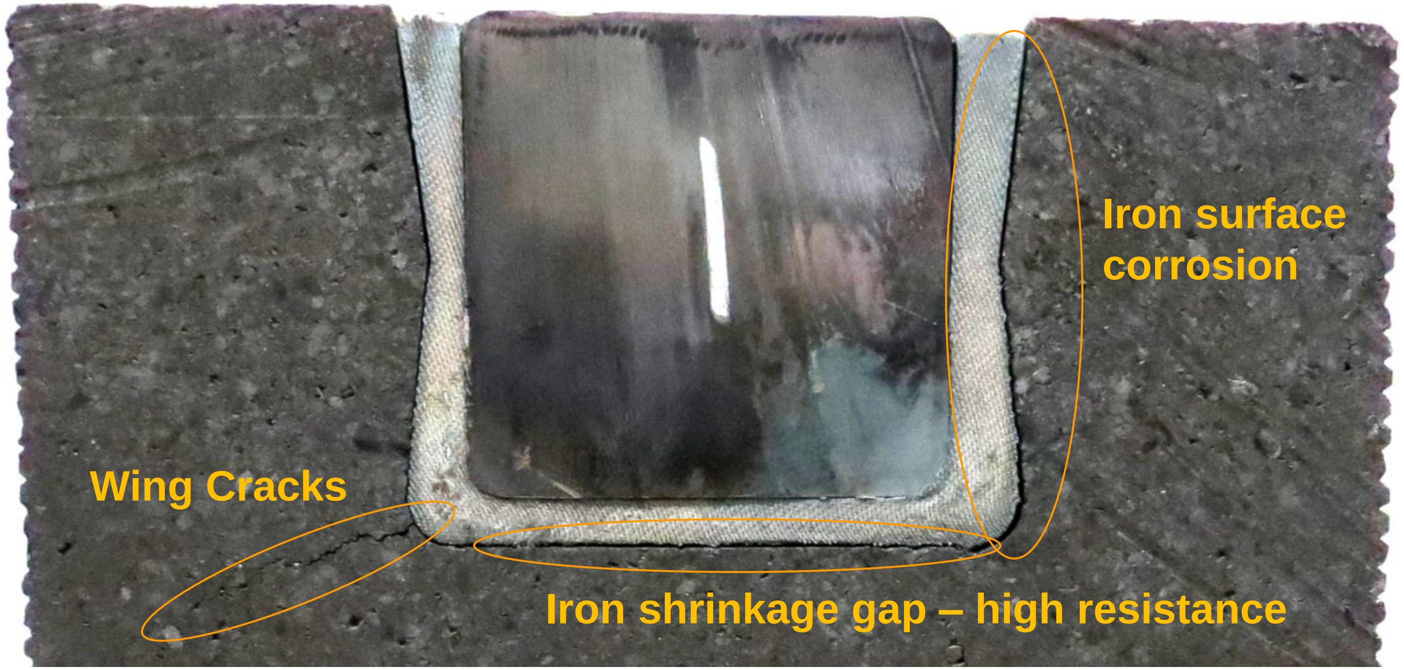


How do Anode Nails Work?

- By reducing the variation in electrical resistance between Cold vs. Hot Anodes from ~ 3:1 to ~ 1.3:1. Additional resistance occurs from frozen bath on newly set anodes.
- This improved uniformity of resistance provides more uniformity of current distribution among stubs within an anode, and between anodes within a pot.



Cathode Assembly: Cathode Nails and shaped iron contact area

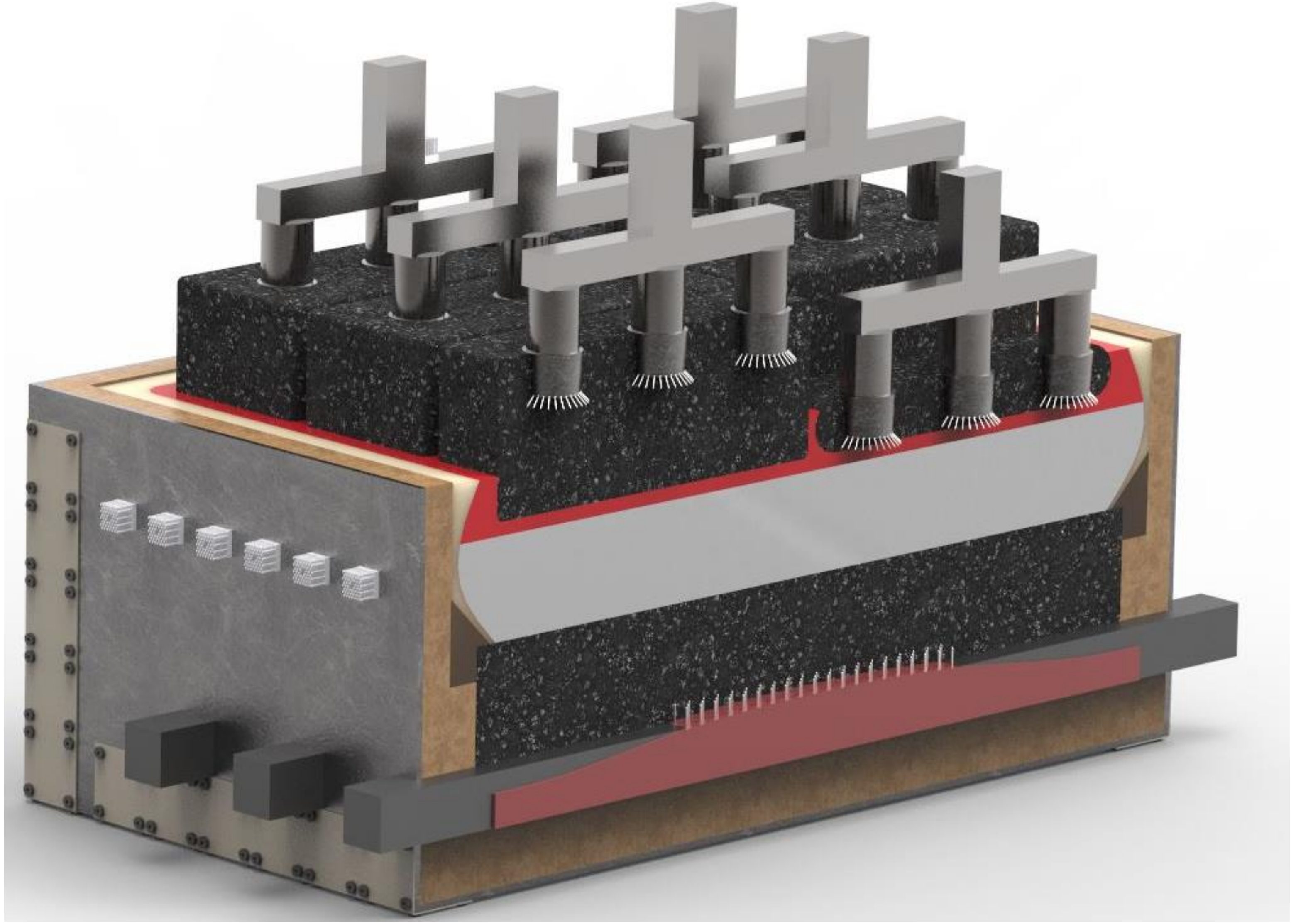


- Iron shrinkage gap → high contact resistance and uneven current distribution.
- Typical increase in ‘Cathode Voltage Drop’ over potlife due to iron corrosion or cracked carbon may be partially overcome by use of cathode nails in the iron/carbon connection.
- Cathode nails: Stainless steel nails, nail pattern selectively reduces contact resistance.
- Gradual reduction in iron contact on collector bar → more uniform current distribution

Combined use of AluCellTech Technologies

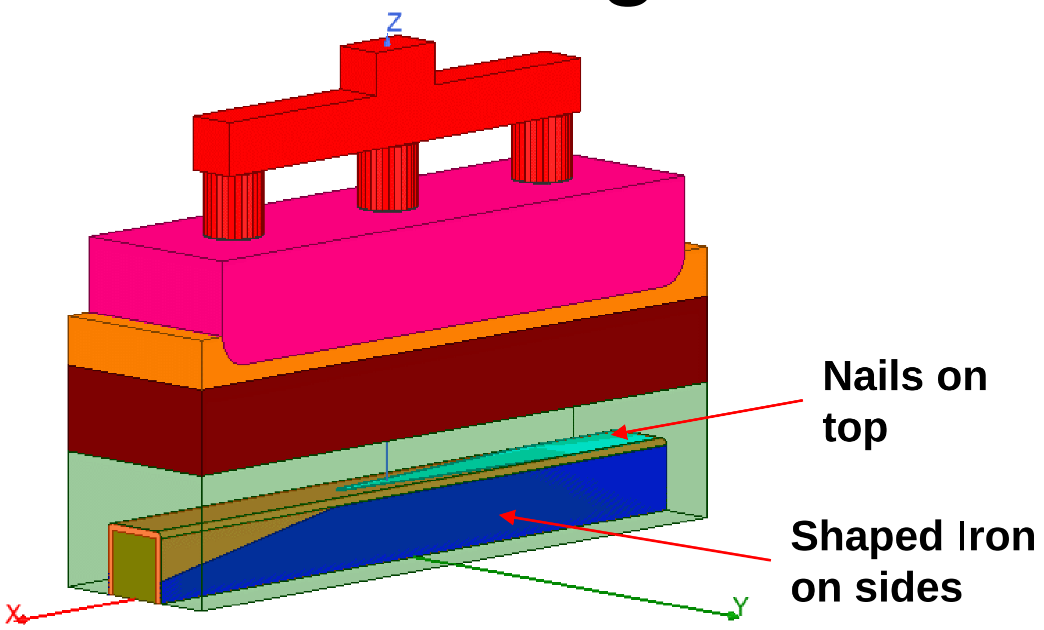
- **Anode nails to reduce power consumption, reduce potnoise**

- **Cathode nails/iron pattern to reduce horizontal electrical currents and peak cathode current density**



ANSYS Current Distribution Modelling

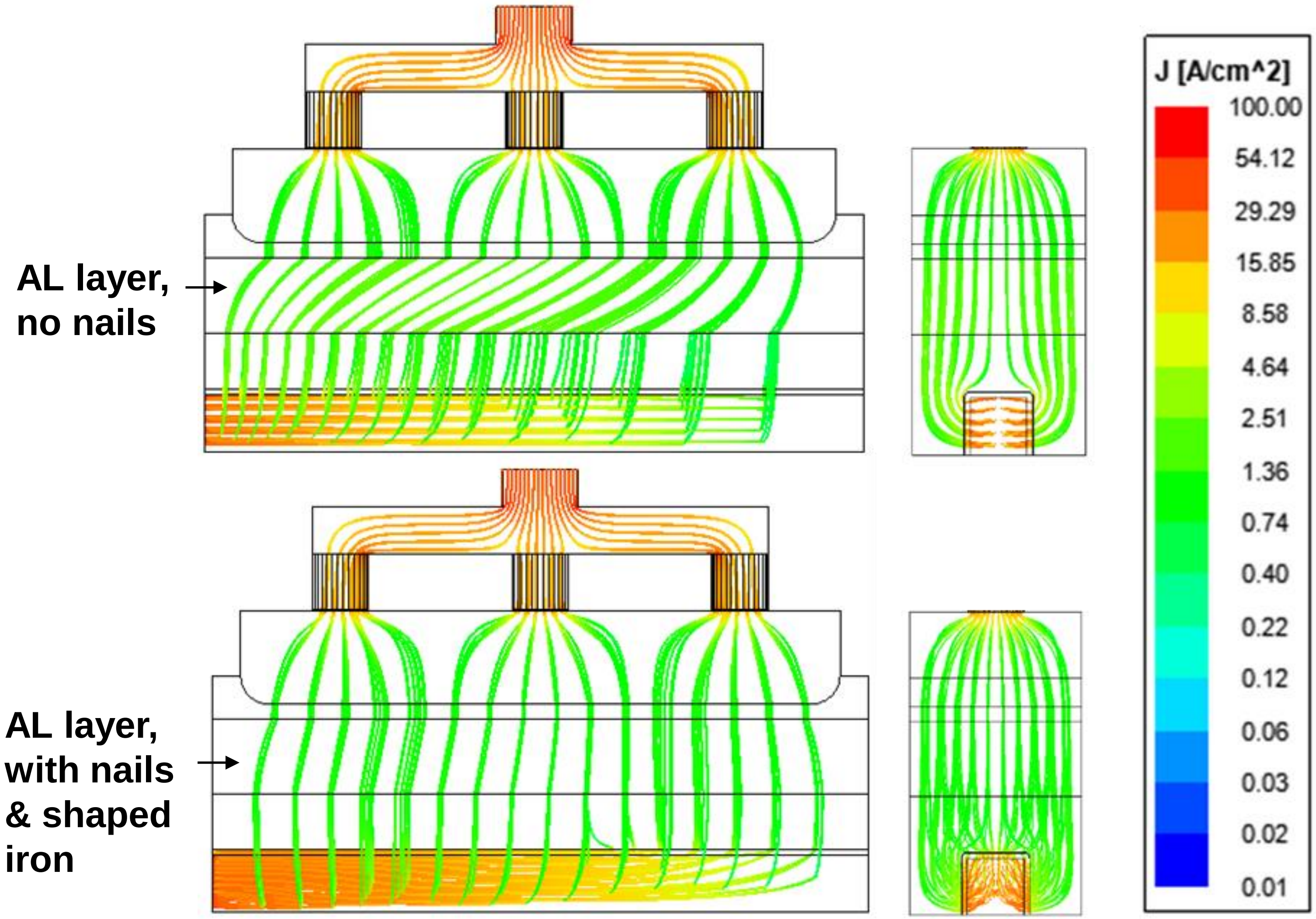
- **Cathode nails reduce resistance, located near center of collector bar**
- **Reduced iron contact area increase resistance near outboard end of collector bar**
- **Nail & iron pattern is optimized by software to reduce cathode current density**



Model Scenarios

- **Base Case: No anode or cathode nails, regular iron pattern**
- **Anode nails**
- **Anode & cathode nails/iron**
- **Anode & Cathode nails/iron – 2 levels of reduced ACD**
- **Anode & Cathode nails/iron – 2 levels of increased amperage**

Reduction in horizontal electrical current in molten Aluminum layer



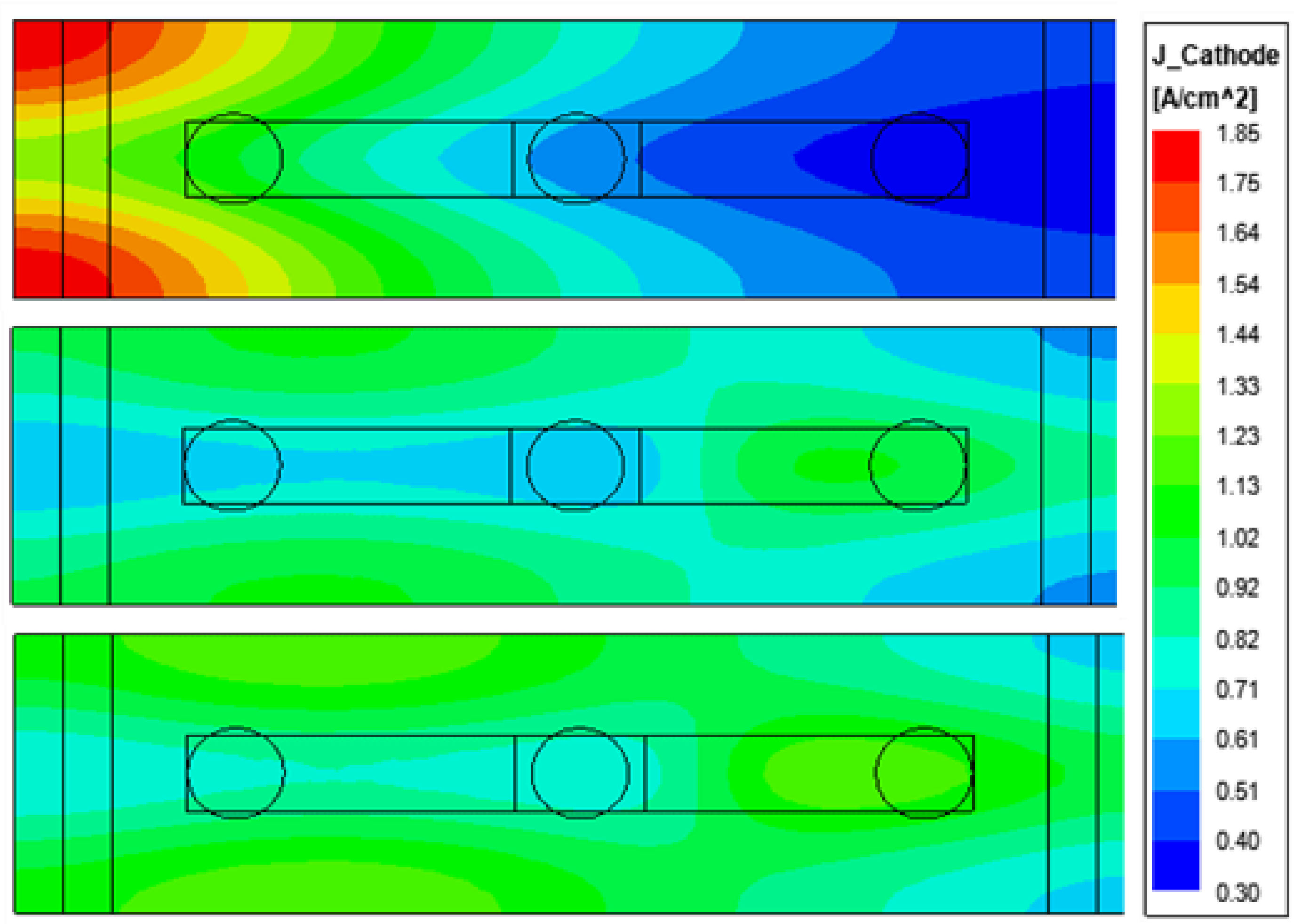
- \- 89% in peak horizontal current density, and - 73% in average horizontal current density in Al layer, center to outboard end.
- \- 38% in peak horizontal current density across cathode width.
- These reductions indicate less potnoise & higher CE%

Reduction in Cathode Current Density

Base Case – No Nails, Anode Current Density 0.90 A/cm²

Optimized Anode & Cathode Nails & Shaped Iron, Anode CD 0.90 A/cm²

Optimized Anode & Cathode Nails & Shaped Iron, Anode CD 1.044 A/cm²



Outboard end **Center of Pot**

- **Original Cathode Current Density is highly imbalanced, 0.31-1.85 A/cm² (1:6)**
- **Cathode nails/iron reduces peak cathode current density by 43%, ~.55-1.05 A/cm², (1:2)**
- **No change to average vertical current density.**

Model ‘potential benefits’ of improved anode & cathode current distribution

- Estimated > 8+% Power Savings kWh/kg, based on Stub to Carbon and reduced ACD resistance savings, and higher CE%,
- Estimated > 2% higher Current Efficiency based on reduced potnoise, however this is a tradeoff to reductions in ACD.
- Estimated > 16% Additional Al Production from higher amperage is enabled based on reduced potnoise, reduced cathode current densities and matching reduced voltage drop with increased amperage.

Model 'potential benefits' of improved anode & cathode current distribution

- Estimated longer potlife, based on reduced cathode current density to reduce the rate of cathode corrosion with more uniform wear. Target > 25% cathode life extension.
- Estimated reduced PFC emissions, based on reduced pot noise and peak voltage potential. Target of > 25% reduction in PFC emissions, (requires verification). Economic savings from carbon taxes.
- Estimated reduced Net Carbon Consumption, from lower STC resistance heating of the anode. Target > 2% NCC savings.

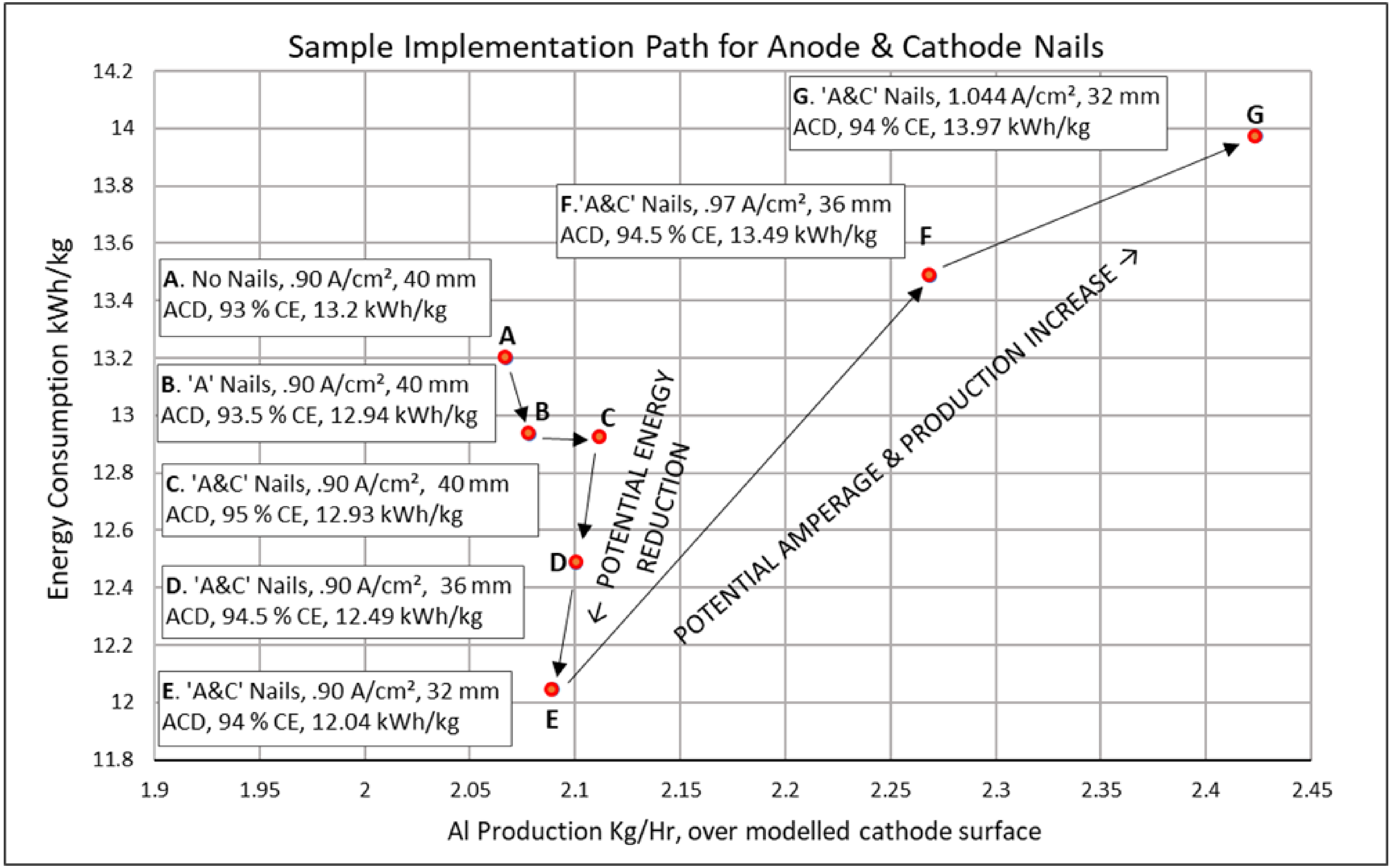
What are the economic benefits?

- Opex cost: Anode nails ~$1.5-$3/ton opex, Cathode nails/iron ~$1/ton Al
- Estimated benefits may return > $60/ton in operating cost. Additional profits might be attained with increased aluminum production.

Implementation

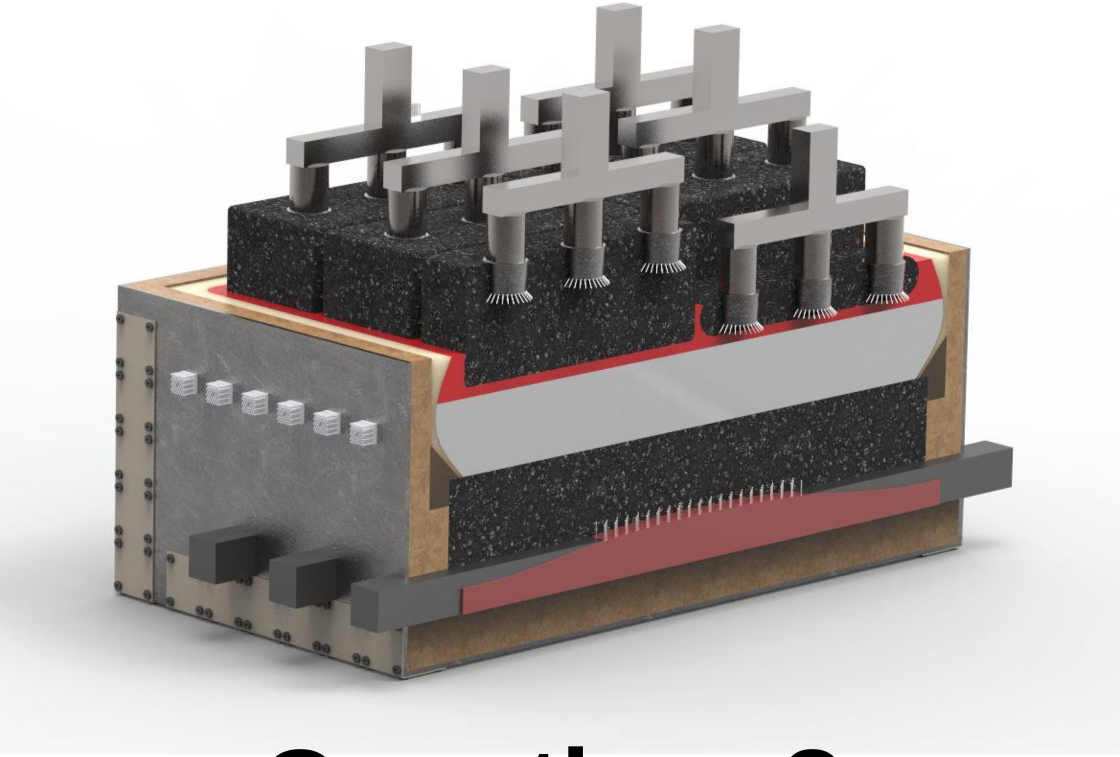
- Step 1: Anode nails to save power and improve CE%, reduced PFC's
- Step 2: Add Cathode nails/iron optimization – improve CE%, save power
- Step 3: Depending on power cost, increase amperage and Al production

Implementation Path



- **Modelled power savings up to 8.8%**
- **Modelled amperage increase up to 16+%**

AluCellTech Anode and Cathode Technologies



Questions?

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