Metaphysics Simulation Story: Defending Automotive Components Against Corrosive Destruction

Helmholtz-Zentrum Geesthacht, Germany

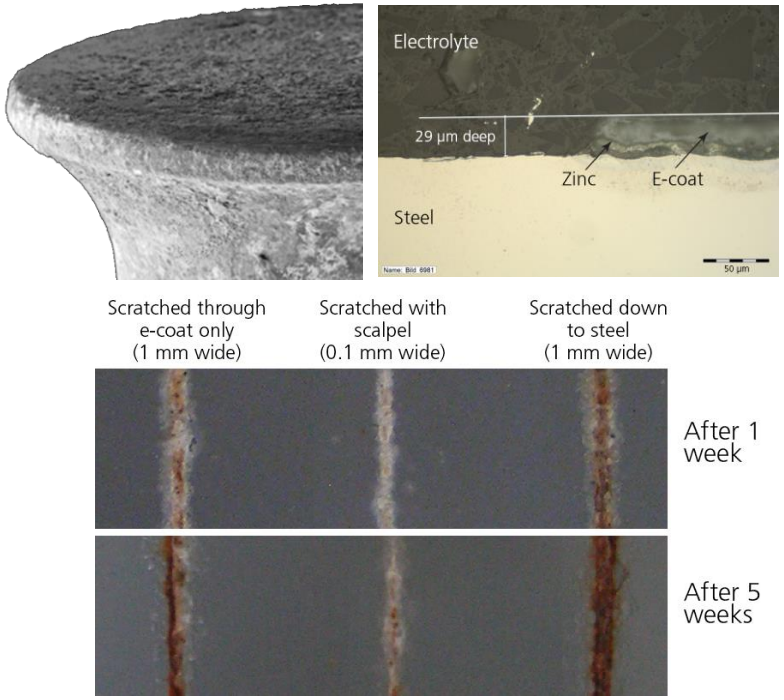
Daniel Höche

Daimler AG, Germany

Nils Bösch

The Challenge

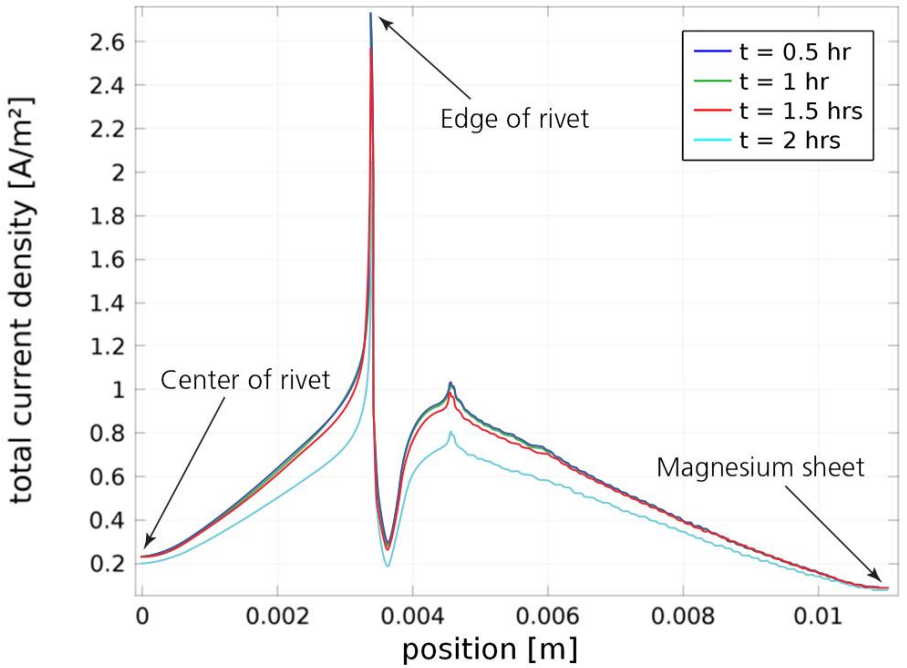
- Galvanic corrosion, caused by chemical reactions between different metals in contact with each other, weakens and eventually degrades areas of sheet metal and rivets in automotive components
    - Material properties, surface roughness, and joining techniques affect the chemical reactions
- Minor defects such as scratches can cause delamination of protective coatings, weakening corrosion protection
- Goal: redesign rivet geometry to minimize corrosion risk



Top left: rivet showing magnesium hydroxide deposit due to corrosion. Top right: cross-section of a test sheet where a scratch has destroyed part of the protective e-coat and zinc. Bottom: corrosion on a galvanized sheet over time.

The Solution

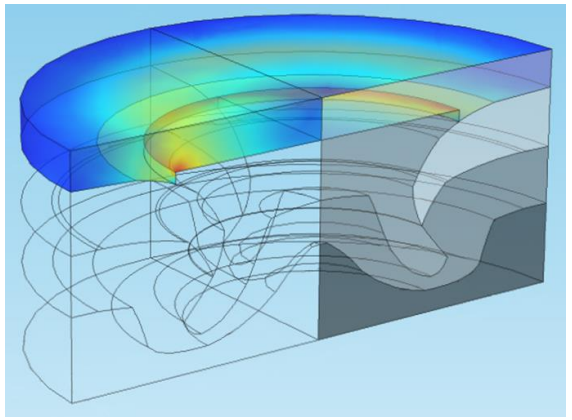
- Identify which geometric factors have the greatest influence on corrosion risk
  - Adjust geometry to minimize corrosion
  - Streamline rivet design and development
- Study variables affecting delamination of coatings that weaken protection
  - Investigate the impact of different sizes and depths of defects in sheet metal

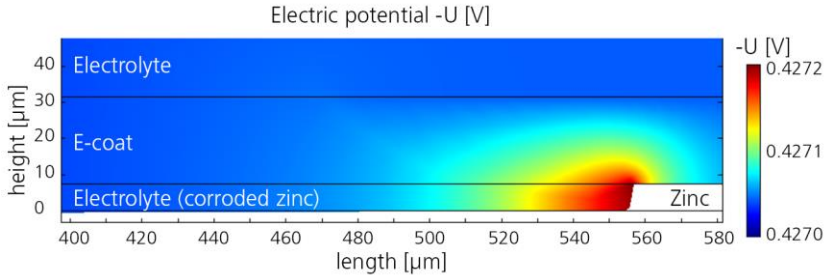


COMSOL plot showing the localized current density at different positions on the surface of a rivet joint.

The Simulation

- Current flow analysis at the interface between rivet and sheet metal
  - Non-constant growth and material properties' influence
  - Predicted decay of adjoined sheets
  - Reduced sharp edges in the rivet joint to minimize exposed area
- Debonding study to analyze the effects of defects on delamination
  - Predicted electric potential in electrolyte and e-coat barrier
  - Recommended an e-coat for the sheet metal that would exhibit the lowest current and therefore the least decay





Top: Current density at the surface of a rivet and sheet metal Bottom: Electric potential in the e-coat and electrolyte in an electrocoated test sheet