

AnAttAI – Experimental and Simulative Analysis of Material- and Surface-Specific Attributes of High-Strength Aluminum Alloy

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Essentials

AnAttAI aims to optimize the welding process of aluminum alloys using artificial intelligence (AI) by analyzing and predicting how different material and surface properties affect the welding results.

Challenges:

- Unpredictable welding results on joining aluminum alloys
- Varying surface layers (Oxide layer; Rolling texture; Passivation layer; Lubricant Layer; Adhesive Layer) impact weld quality

Goals & Approach:

- Characterize surface layers and develop measurement methods.
- Combine experimental investigations with simulation-based analyses to gain a deep understanding of welding characteristics.
- Optimize welding through AI-driven process improvements.

AI-Driven Optimization of Welding Processes

Input:

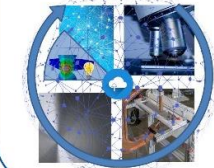
- Surface layer data
- Welding parameter
- Expert knowledge



Output:

- Optimized welding suggestions
- Explanation of welding results

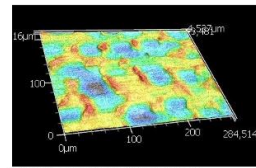
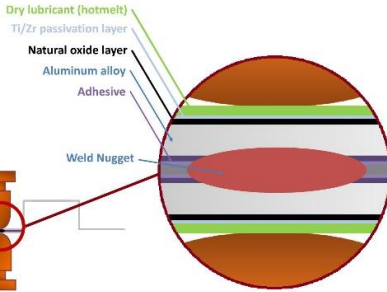
- AI analyzes correlations
- LLM standardizes data
- Ontology development
- Continuous refinement of data



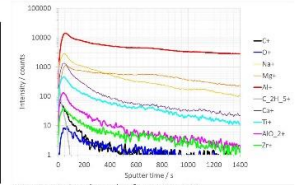
Surface Investigation

Analysis methods & results

1. Texture of Aluminum Sheet: SEM, WLI, Confocal Laser
2. Oxide Layer: SEM, TEM, AES, TOF-SIMS, XPS
3. Passivation Layer: TEM, AES, TOF-SIMS, XPS, XRF, Ellipsometry

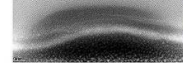


EDT Surface of EN AW-5182 Aluminum Sheet (Keyence VK-X3000) (2024)



TOF-SIMS signal result of EN AW-5182 (thankfully analyzed by Wolfram Hempel from ZSW) (2024)

High-angle annular dark-field imaging



Sample: EN AW-5182; Ti-Zr Passivation; EDT (September 16, 2024)

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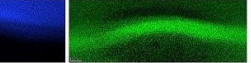
Wi et al. (2024)

AI-Mapping



Ti-Mapping

O-Mapping



Zr-Mapping

Workflow

Electrical-thermal and mechanical subproblems are advanced in a segregated fixed-point loop:

- Electro-thermal solve.
- Mechanical-contact update.
- Interface-resistance refresh.
- Convergence.

Yielding greater robustness than fully coupled schemes. A Python-orchestrated automation chain executes pre/solve/post steps and parametric sweeps within Jupyter notebook, shortening turnaround and improving efficiency.

