Kinetic Metallization™
Repair of Alclad

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Howard Gabel, R. Tapphorn, K. Hashimoto and T. Crowe
Kinetic Metalization Alternative for Al Based Coatings

CP Al  
Al-Trans®/Cr  
4047 Braze Alloy

INOVATI
Alclad™ Alcoa

Low alloy environmental layer
Hot roll bonded to
High strength Al

Corrosion protection

High-gloss finish
First use 1927
Problem
Requirements
Functional

- Adhesion
- Polishable
  - conventional compounds/techniques
Decorative

- Color space
- Optically distortion free
  - low porosity
- smear resistance
Alclad Repair Leading Edge

Before

After
Alclad Repair

- Pure Al coating on 2024 Al substrate
- Coating thickness: 7 mils
- Polished to mirror finish using same method used on Alclad
Solution

- Deposition equipment
- Gun translation
- Feedstock
Introduction to KM

- Metal deposition through particle impact
- Low-temperature << melting point
- Low noise < 75 dBa @ 1 m
- Highest quality — Lowest cost
Sonic Mach 1 Nozzle

- High particle velocity > 750 m/s
- Pressure < 1 MPa (150 psig)
- Temperatures to 1100°C
- Powder preheater & mixer
- Powder injection at nozzle inlet

Substrate
Sonic Mach 1 Nozzle

- High particle velocity > 750 m/s
- Pressure < 1 MPa (150 psig)
- Temperatures to 1100°C
- Powder injection at nozzle inlet
- Powder preheater & mixer

Substrate
KM-Production Coating System

- Robotic KM Spray Gun
- Data accession and process control
- Gas flow control
Kinetic Metallization™ Process

Potential Energy

Powder

Heat

Kinetic Energy
Kinetic Metallization™ Process

Potential Energy

Powder

Heat

Kinetic Energy
Kinetic Metallization™ Process

- Gas Storage System
- 2.5 kW Thermal Conditioning Unit < 150 psig
- Ultra-fine Powder Fluidizing Unit
- Sonic Deposition Nozzle with Powder Preheater & Mixer
KM-Mobile Coating System (KM-MCS)

- KM-Mobile Coating System
  - Handheld KM Spray Gun
  - Brush-sieve powder fluidizing units
  - Integrated subsystems on cart
- Applicable Coatings (e.g.)
  - Air/GN2 (Al-Trans®, Cu, Zn, Ni)
  - He/GN2 (WC-Co, Ni alloys, Nb, Ta)
  - Composite polymers (PEEK, PTFE)
Al-Trans® IVD Aluminum Repairs

- Surface Repair of IVD Al coating
  - Alternative to brush cadmium repairs
  - Environmentally compliant
- Al-Trans® Coating Properties on High Strength Steels
  - Adhesion of > 10 ksi without de-lamination
  - Coating protection >3000 hrs in salt fog per ASTM B117
  - Superior corrosion protection in SO2 salt fog per ASTM-G85
  - Passed Joint Test Protocol-2003 specifications
Al-Trans® On Steel

- Al-Trans® mixture
  - Aluminum
  - Transition metal
- Adhesion to:
  - Substrate: ASTM B571
  - Paint: ASTM D2794, 120 ft-lb
- Corrosion
  - ASTM B117, 5,000 hrs
Al-Trans® Corrosion Protection
IVD-Al Repairs

- Composite Al-Trans®/Cr Coating
- Properties
  - Hardness HRB = 62
  - Porosity < 0.5%
  - Corrosion - Salt Fog B117
  - 3000 Hrs
  - Substrate 4130 steel
KM Repair Sequence for IVD-Al

- IVD-Al Removed
- Feather Edges
- KM Al-Trans® Repair
## Al-Trans® Kinetic Metallization
### JTP-2003 Qualification Tests

<table>
<thead>
<tr>
<th>Reparability Test</th>
<th>JTP</th>
<th>Acceptance Criteria</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unscribed Salt Fog</td>
<td>3.3.1 3.7.1</td>
<td>3000 Hrs ASTM B117-94</td>
<td>Pass</td>
</tr>
<tr>
<td>Scribed Salt Fog</td>
<td>3.3.2 3.7.1</td>
<td>1000 Hrs ASTM B117-94</td>
<td>Pass</td>
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<tr>
<td>Unscribed SO2 Salt Fog</td>
<td>4.1.1</td>
<td>500 Hrs ASTM G85</td>
<td>Pass</td>
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<tr>
<td>Scribed SO2 Salt Fog</td>
<td>4.1.2</td>
<td>500 Hrs ASTM G85</td>
<td>Pass</td>
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<tr>
<td>Unscribed Salt Fog</td>
<td>3.1.4</td>
<td>3000 Hrs ASTM B117-94</td>
<td>Pass</td>
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# Al-Trans® Kinetic Metallization
## JTP-2003 Qualification Tests

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<tr>
<td>Hydrogen Embrittlement</td>
<td>3.6.1</td>
<td>200 Hr/75% ASTM F519</td>
<td>Pass</td>
</tr>
<tr>
<td>Hydrogen Re-Embrittlement</td>
<td>3.7.1</td>
<td>200 Hr/75% ASTM F519</td>
<td>Pass</td>
</tr>
<tr>
<td>Corrosion Resistance 14 Fluids</td>
<td>3.3.4</td>
<td>No Coat Degradation Compared to Brush Cd</td>
<td>Pass</td>
</tr>
<tr>
<td>Stress Corrosion Cracking</td>
<td>4.3</td>
<td>SEM Fractography</td>
<td>Pass</td>
</tr>
<tr>
<td>Scribed Painted Coating</td>
<td>3.3.5</td>
<td>3000 Hrs ASTM B117 - 94</td>
<td>Pass</td>
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4047 Braze Alloy Deposition

- Alternative to foil or paste
- KM handheld gun enables deposition on complex geometry
- Uniform braze joint
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4047 Braze Joint

- 4047 Braze alloy
- Controlled atmosphere brazing
- Al-K-F Flux
4047 Braze Joint Detail

- High quality braze
- Good wetting
- Uniform distribution
- Minimal grain boundary penetration
Summary

❖ KM Al base coatings offer alternatives to existing processes
❖ CP Al coating replacement/repair of Alclad
❖ Al-Trans®/Cr replacement/repair of Al IVD Coatings
❖ 4047 Braze alloy depositon replacement of braze foil or paste
Latest Development

- KM-1373
- Highest temperature available
- Lowest gas flow available
- Highest quality coatings
- Lowest cost coatings