GMAW CONSUMABLE INNOVATIONS TO IMPROVE WELDING QUALITY ON ZINC-COATED STEELS

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WELDING QUALITY CHALLENGES WITH ZINC-COATED STEEL

Challenge #1: Paint Adhesion
Incompatible with acid descaling \(^{[1]}\)

Silicon-based slag obstructs post-weld coating adhesion

Corrosion vulnerability of the weld surface

Challenge #2: Weld Quality
Zinc-based porosity

Compromises fusion zone mechanical properties

Pre-mature failure of welded components \(^{[2]}\)
GMAW OF ZINC-COATED STEEL

SuperArc® XLS

- Solid, copper coated GMAW wire
- Engineered to reduce silicon-based slag formation

Alternative solution for zinc-coated steel [3]

- Improved post-weld coating adhesion and corrosion resistance
SURFACE SILICATE V. SURFACE OXIDE

ER70S-3

Non-conductive slag impairs the painting process

Uncoated materials: Acid descale for surface cleaning

Coated materials: Incompatible with acid descale

4.2 mm uncoated HSLA 550, no acid descale

SuperArc® XLS

Electro-coated

As-welded

120 CCT*

Electro-coated

As-welded

120 CCT*

* CCT = Cyclic Corrosion Test
WELDING QUALITY CHALLENGES WITH ZINC-COATED STEEL

**Challenge #1: Paint Adhesion**
- Incompatible with acid descaling \[^{[1]}\]
  - Silicon-based slag obstructs post-weld coating adhesion
  - Corrosion vulnerability of the weld surface

**Challenge #2: Weld Quality**
- Zinc-based porosity
  - Compromises fusion zone mechanical properties
  - Pre-mature failure of welded components \[^{[2]}\]
REALITIES OF WELDING ZINC-COATED STEEL

• Zinc contamination:
  – Weld metal solidification traps zinc vapor
    • Porosity → weld integrity concerns

• Zinc-coated steel welding:
  – Slower travel speeds
  – Spatter → 5x greater than uncoated steel
  – Fume generation and exposure → 3.5x higher particulate
POROSITY AS A DEFECT

Example industry specification:
- 6mm of porosity allowed per 25mm of linear weld
- 10% by area for a 3mm fillet

Visible/external: > 5% by area
Ideal condition: < 3% by area

1% or less

5% or more
GMAW OF ZINC-COATED STEEL

SuperArc® XLS

- Solid, copper coated GMAW wire
- Engineered to reduce silicon-based oxide formation

Alternative solution for zinc-coated steel

- Improved post-weld coating adhesion and corrosion resistance
- Reduced internal porosity
Question: How does zinc interact with the weld pool differently between ER70S-3 and SuperArc® XLS?
EXPERIMENT

Objective: to compare the interaction of zinc vapor with the weld pool for two electrodes:
- ER70S-3 and SuperArc® XLS

Test: observe zinc vapor behavior via two in situ imaging methods:
1. High-speed X-ray video to show inside the weld pool
2. High-speed video of weld pool surface

<table>
<thead>
<tr>
<th>Joint Type</th>
<th>lap, zero gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shielding Gas</td>
<td>90% Argon / 10% CO₂</td>
</tr>
<tr>
<td>Welding Process</td>
<td>(1) Rapid X®, (2) Rapid X® LS</td>
</tr>
<tr>
<td>Travel Speed</td>
<td>40 in/min (1 m/min)</td>
</tr>
<tr>
<td>Contact Tip to Work Distance</td>
<td>3/4” (19 mm)</td>
</tr>
<tr>
<td>Electrode Size</td>
<td>0.045”</td>
</tr>
<tr>
<td>Electrode Type</td>
<td>(1) ER70S-3, (2) SuperArc® XLS</td>
</tr>
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</table>
TEST 1: HIGH-SPEED X-RAY VIDEO

Test Plan
• Weld 5 joints with each electrode
• Capture X-ray video at 1000 fps

Response
• X-ray video analysis
  – Characterize behavior of zinc vapor inside the weld pool

<table>
<thead>
<tr>
<th>Base Material Thickness</th>
<th>2.0 mm</th>
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<tbody>
<tr>
<td>Base Material Type</td>
<td>HSLA 550</td>
</tr>
<tr>
<td>Coating Type</td>
<td>Hot Dipped Galvanized (GI)</td>
</tr>
<tr>
<td>Coating Weight</td>
<td>50G/50G</td>
</tr>
<tr>
<td>Welding Position</td>
<td>horizontal</td>
</tr>
</tbody>
</table>
TEST 1: 3 REGIONS OF ZINC VAPOR BEHAVIOR
TEST 1: HIGH-SPEED X-RAY VIDEO CLIPS

ER70S-3

SuperArc® XLS
TEST 2: HIGH-SPEED VIDEO OF OUTGASSING

Test Plan
• Weld 5 joints with each electrode
• Capture video at 2500 fps

Responses
• High-speed video analysis
  – Characterize zinc vapor outgassing in the near-arc region
• Post-weld X-ray, porosity by % area

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</table>
TEST 2: OUTGASSING VIDEO CLIPS

ER70S-3

SuperArc® XLS

Outgassing Event Map

Distance from Weld Pool Edge (mm)

Distance Relative to Electrode (mm)

Electrode Tip

Outgassing Event Map

Distance from Weld Pool Edge (mm)

Distance Relative to Electrode (mm)

Electrode Tip
SuperArc® XLS showed 38% less porosity in post-weld X-rays.
CONCLUSIONS

Improved welding on zinc-coated steels with SuperArc® XLS

• Slag improvements impact paint adhesion
  • Increase corrosion life of welded regions

SupercArc® XLS exhibited a fundamentally distinct interaction with zinc vapor in the weld pool

• 3x more outgassing events
• Unique location of outgassing events
  • Close to the arc
  • Region of greatest benefit
• Lower porosity improves productivity and quality
  • Increases travel speeds
  • Improves internal weld quality
QUESTIONS

References


FOR MORE INFORMATION

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