Mixed Material Joining – A/SP Research Results Webinar

FATIGUE AND CORROSION EVALUATION
JULY 8, 2020
Mixed Material Joining – A/SP Research Results Webinar

Introduction: John Catterall
Vice President, Automotive Program
American Iron and Steel Institute
Mixed Material Joining – A/SP Research Results Webinar

Presenter: Bryan Macek
Senior Technical Specialist
FCA US LLC
Project Team Members

JPC Project Mentor: Jonathan Powers, AK Steel
Project Leader: Bryan Macek, FCA US LLC
Project Manager: Wendy Dillingham, Auto/Steel Partnership

Project Team Members:
- Hesham Ezzat, AISI
- Qaiser Khan, ArcelorMittal
- Zhifen Wang, ArcelorMittal
- Rick Johnson, FCA US LLC
- Michael Shaw, FCA US LLC
- Kevin Ward, FCA US LLC
- Steve Gallagher, Ford Motor Company
- Adam Ballard, General Motors Company
- Steven Cipriano, General Motors Company
- Arnie Newsome, Nucor Corporation
- Hokook Lee, Posco
- Paul McKune, Martinrea
- Michael Danyo, Ford Motor Company
Project Goals

• Enable automotive OEMs to quickly and confidently implement the mixed material joining technologies that are best suited for their respective manufacturing footprints and business models.

• Construct and populate a mixed material structural joint performance knowledge base that will be accessible to the A/SP member companies.

• Enable future exploration of other technologies as they become available in a standardized and proven fashion.
Project Approach

Developed a test matrix
  • Baseline steel gauge and grade combinations to serve as reference points
  • Aluminum replacement for Bake Hardenable steel
  • Joining Technologies
  • Test Type
  • Joint Configurations

Conducted Quasi-static strength test as a preliminary filter
  • Selected (3) technologies
    • Resistance Element Weld
    • Friction Rivet
    • Solid Self-Piercing Rivet

Phase 2
  • Added additional suppliers for selected technologies
  • Repeated quasi-static testing
  • Performed cyclic fatigue testing
  • Performed corrosion testing
Terminology

Naming conventions adopted to avoid trademarks and company-specific naming

- Resistance Spot Weld (RSW) - Baseline
- SPR, Solid (SPR-Solid)
- Friction Rivet (FR)
- Resistance Element Weld (REW)
Lap Shear

2T

105 mm

25 mm

45 mm

3T

105 mm

25 mm

45 mm

Bare

Adhesive

Sealer

Aluminum

Steel

Adhesive

Sealer

American Iron and Steel Institute
Quasi-Static — Resistance Spot Weld

2T Joint Without Adhesive (Top Left)
2T Joint With Adhesive (Top Right)
3T Joint (Bottom Left)
Cyclic — Resistance Spot Weld

2T Joint Without Adhesive (Top Left)
2T Joint With Adhesive (Top Right)
3T Joint (Bottom Left)
Quasi-Static — Solid Self-Piercing Rivet

2T Joint With Sealer (Top Left)
2T Joint With Adhesive (Top Right)
3T Joint (Bottom Left)
Cyclic — Solid Self-Piercing Rivet

2T Joint With Sealer (Top Left)
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3T Joint (Bottom Left)
## Results Matrix – Solid Self-Pierce Rivet

**Peak Loads**

<table>
<thead>
<tr>
<th>Joint ID</th>
<th>2T / 3T</th>
<th>Mat 1</th>
<th>Mat 2</th>
<th>Mat 3</th>
<th>RSW</th>
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</tr>
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<tbody>
<tr>
<td>Joint 1</td>
<td>2T</td>
<td>BH210 (for RSW)</td>
<td>PHS 1.6</td>
<td>-</td>
<td>w/o Adh.</td>
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</tr>
<tr>
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</tr>
<tr>
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**Energy at Break**

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**Versus RSW Baseline**

| >100% | ≥80% | ≥60% | <60% | No Data |

- **Peak Loads**: 
  - Good results for 2T joining
  - Reduced performance with thin (1.0 mm, 1.2 mm) bottom sheets

- **Energy at Break**: 
  - Reduced 2T adhesive performance versus RSW
  - 2T RSW joints with adhesive failed in base material, not at joint
  - 3T joints performance better than RSW

- **Cyclic**: 
  - 2T joints with adhesive tested at higher loads
  - Reduced 2T adhesive performance versus RSW
  - 2T RSW joints with adhesive failed in base material, not at joint
Quasi-Static– Resistance Element Weld

2T Joint With Sealer (Top Left)
2T Joint With Adhesive (Top Right)
3T Joint (Bottom Left)
Cyclic – Resistance Element Weld

2T Joint With Sealer (Top Left)
2T Joint With Adhesive (Top Right)
3T Joint (Bottom Left)
### Results Matrix — Resistance Element Weld

**Peak Loads**

- Both suppliers worked well for 2T joining
- Reduced performance with thin (1.0mm, 1.2mm) bottom sheets

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**Energy at Break**

- Reduced adhesive performance versus RSW
- 2T RSW with adhesive failed in base material, not at joint
- Adhesive failure to aluminum top sheet noted in 2T joints

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**Cyclic**

- 2T joints with adhesive tested at higher loads
- Reduced adhesive performance versus RSW
- 2T RSW joints with adhesive failed in base material, not at joint

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**Versus RSW Baseline**

- ≥100%
- ≥80%
- ≥60%
- <60%
- No Data
Quasi-Static — Friction Rivet

2T Joint With Sealer (Top Left)
2T Joint With Adhesive (Top Right)
Cyclic — Friction Rivet

2T Joint With Sealer (Top Left)
2T Joint With Adhesive (Top Right)
## Results Matrix — Friction Rivet

### Peak Loads

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<th>Joint ID</th>
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- Both suppliers worked adequately for 2T joining
- Friction Rivets not suitable for 3T joining

### Energy at Break

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- Reduced adhesive performance versus RSW
- 2T RSW joints with adhesive failed in base material, not at joint
- Adhesive failure to aluminum top sheet noted in 2T joints

### Cyclic

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- 2T joints with adhesive tested at higher loads
- Reduced adhesive performance versus RSW
- 2T RSW joints with adhesive failed in base material, not at joint

### Versus RSW Baseline

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- ≥80%
- ≥60%
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19 | American Iron and Steel Institute
Corrosion — Resistance Spot Weld

2T Joint Without Adhesive (Top Left)
2T Joint With Adhesive (Top Right)
3T Joint (Bottom Left)
Corrosion — Solid Self-Piercing Rivet

2T Joint With Sealer (Top Left)
2T Joint With Adhesive (Top Right)
3T Joint (Bottom Left)
Corrosion — Resistance Element Weld

2T Joint With Sealer (Top Left)
2T Joint With Adhesive (Top Right)
3T Joint (Bottom Left)
Corrosion — Friction Rivet

2T Joint With Sealer (Top Left)
2T Joint With Adhesive
Project Conclusions and Recommendations

All (3) selected technologies performed adequately for 2T joining

Resistance Element Welding (REW) and Solid Self Piercing Rivets (SPR, Solid) were suitable for 3T joining, depending on the material stack

Solid Self Piercing Rivets (SPR, Solid) absorbed significantly more energy than the baseline Resistance Spot Weld

Recommendations

• Further study of interactions between joining methods and structural adhesive
• Comparison of emerging technologies, such as Thermally Assisted Clinching and Thermally Assisted Self Piercing Rivets to existing data
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Thank You / For More Information

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Join AISI for a review of Liquid Metal Embrittlement (LME) research results from Auto/Steel Partnership presented by Michael Karagoulis, Ph.D., Master Mechanic - Weld Development, Global ME Body-in-White @ GM.

A/SP has been working collaboratively with OEMs to develop rapid evaluation procedures to help the industry overcome the challenge of LME to help speed validation of certain grades, such as TRIP and Gen 3 steels.

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