Thermal Integrated Clinching Process - Innovative Joining of Next Gen. of AHSS

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Strategic Development Partners

ARCELORMITTAL:
• ArcelorMittal is the leading supplier of quality steel in automotive market.
• Global R&D EC provides mechanical and metallurgical support and testing support for process window and optimization of AHSS Thermal Integrated joining
• Technical support on requirements of joining strength for light-weighting and occupant safety

TOX PRESSOTECHNIK:
• Supply clinch tooling and electro-mechanical drives
• Collaboration investigating the process for mechanical joining a complete vehicle
• Global technical support

COHERENT Inc.
• Manufacture of our Diode Lasers
• Design and supply of Collimators and Optics
• Global technical support
Applications and Objective

Fasteners attachment during assembly   Down gauging for light weighting

→ Need for joining technology for a wide range of steel stack ups and complex BIW assemblies

**Clinching | Mechanical Joining:**
- Non additive widely accepted mechanical joining technique
- Reduce energy consumption and CO₂ emissions
- Capable of joining 3G AHSS

**Self Pierce Riveting | Mechanical Joining:**
- Aluminum and thin sheets to AHSS
- Mechanical joining of 3 & 4T stack-ups

**Thermal Integrated Clinching Assembly™**
- Apply controlled heat zone for mechanical joining
- Exceptional Joint Strength & Dynamics
- Suitable for complex AHSS and UHSS
- Compatible with existing facility layout.

Example AHSS BIW - VOLVO XC-90 Platform
Robotic Thermal Clinching Assembly™

A complete Class 1 Laser product integrated on assembly floor with no laser booth requirements and is mounted and easily interfaces to any 210KG robot. **Available throughout North America April 2018.**
This Pedestal Fixture is designed for Thermal Clinching of part depths up 42” and Thermal Integrated clinching and all types of clinch nuts to AHSS and UHSS materials.
# Class 1 Validation Test

## ALLOWABLE EMISSION TESTING

<table>
<thead>
<tr>
<th>Wave length</th>
<th>980 nm</th>
<th>Date</th>
<th>28-Mar-18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hold down Force</td>
<td>2.5KN</td>
<td>Material:</td>
<td>Coupon 1: Usobor-1500 1.5mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coupon 2: Usobor-1500 1.5mm</td>
</tr>
</tbody>
</table>

Test Engineer: R. Lemanski

Allowable limits: ≥1.72 mill watts (mW)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Power</th>
<th>Time/seconds</th>
<th>Radiation</th>
<th>Radiation</th>
<th>Radiation</th>
<th>Radiation</th>
<th>Radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3KW</td>
<td>3</td>
<td>61.6</td>
<td>59.74</td>
<td>56.72</td>
<td>59.69</td>
<td>59.44</td>
</tr>
<tr>
<td>1</td>
<td>3KW</td>
<td>3.5</td>
<td>59.71</td>
<td>40.33</td>
<td>55.73</td>
<td>57.82</td>
<td>53.40</td>
</tr>
</tbody>
</table>

All values are in MICRO Watts (μW)

- The UTICA Thermal Clinching Assembly emits much less radiation than a typical laser pointer.
Robotic Thermal Integrated Clinching
Potential Energy Savings Clinching Vehicle

11.7% Overall Energy Reduction – Based on 500K units

Average manufacturing energy usage per Generic 3,370 pound vehicle, Stamping & Assembly Plant usage only:
- Total kWh per vehicle: 684
- Vehicles per month: 41,666
- Total kWh per month: 28,500,000
- Yearly kwh usage: 342,000,000
- Yearly energy cost: $26,060,400.00

Average welding energy usage at assembly for generic 3,370 pound vehicle, assumes 4,000 joints:
- Total kWh per unit: 80
- Units per month: 41,666
- Total kWh per month: 3,333,280
- Yearly kwh usage: 39,999,360
- Yearly energy savings: $3,047,951.00

Ref. US DOE, Argonne National Laboratory study ANL/ESD/10-6
Process Optimization

- Process optimization and mechanism understanding for joint strength/quality:
  - Majority of work focused on Usibor®1500 and Usibor® 2000 process optimization for:
    - Feasibility of Clinching for AHSS beyond 1000 MPa
    - Improvement of TSS
    - Improvement of CTS
    - Mechanism understanding of process optimization
  - Studied homogenous stackups:
    - 1.5mm GA TRIP780
    - 1.5 mm Usibor®1500
    - 1.0 mm Usibor®1500
    - 1.6 mm Usibor® 2000
Joint Strength: Tension Shear Strength

- Tension-Shear strength improvement by thermal Integrated Clinching compared to Cold Clinching.
Joint Strength: Cross-Tension Strength

- Cross-Tension Strength Improvement By Thermal Integrated Clinching
Mechanism for Process Optimization

- Too low temperature couldn’t soften the top sheet enough at the necking area for material flow.
- Too high temperature with coarse/brittle microstructure should be avoided.

1.5mm Usibor®1500 @500°C, 850°C, 1050°C
Mechanism for Process Optimization

1.0mm Usibor®1500 @ 500°C, 850°C, 1050°C

- Too high temperature for thin sheets can damage bottom sheet.
Mechanism for Process Optimization

- Spot welds have a soft heat-effected zone which is surrounded by a hard nugget and makes it susceptible to failure.

- Extreme temperatures causing coarse/brittle microstructure can be avoided with the Thermal Integrated Clinching method.
Mechanism for Process Optimization

Representative Cross Section

- Upper sheet neck thickness $t_N$ determines joint strength in most applications.
- Remaining combined thickness $X$ is controlled and closely related to $t_N$. 
Mechanism for Process Optimization

Necking Thickness

- Increasing of necking thickness increases TSS and CTS.
Thermal Integrated Clinch Nuts

- Thermal Clinch Joint is stronger than class 10 clinch nuts.
- Class-12 Pierce Clinch Nuts are being developed now.
**PHS Thermal Integrated Clinch Nut Results**

Push out force and torque data for self-piercing clinch nut.

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness</th>
<th>Nuts</th>
<th>Push out force (N)</th>
<th>Torque (N.m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usibor® 1500</td>
<td>1.0 mm</td>
<td>KP 6-S-10</td>
<td>1260</td>
<td>30</td>
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<tr>
<td>Usibor® 1500</td>
<td>1.5 mm</td>
<td>KP 8-H-10</td>
<td>7000</td>
<td>66</td>
</tr>
<tr>
<td>Usibor® 2000</td>
<td>1.6 mm</td>
<td>KP 8-H-10</td>
<td>7400</td>
<td>67</td>
</tr>
</tbody>
</table>

Clinched nuts pushout strength exceed OEMs specification.
Summary

• Thermal Integrated Mechanical Joining is suitable for current and Next Gen. AHSS where resistance spot-weld fails regarding strength and weld quality.

• Thermal Integrated Clinching process does not require laser booth for operator safety.

• There are benefits in case of energy and cost saving over the time as compared to resistance spot-weld methodology.

• Influencing parameters for determination of Thermal Integrated Clinching windows process was developed:
  
o Temperature/heat should be high enough to ensure the top sheet is ductile enough to deform, especially at the total width of the necking area.
  
o Too high temperature/time should be avoided to avoid tempering of martensite extensively and surface breaking especially for thin material.

• A good combination of Joining Strength (Cross-Tension and Tension–Shear Strength “CTS and TSS”) was achieved after process optimization.
Next Steps

• Continue the study on next Gen. AHSS (Zn Coated 3rd Gen. AHSS).

• Working with OEMs to adequately implement alternative joining solution where resistance spot-weld fails for Next Gen. AHSS.

• Dissimilar Thermal Integrated clinching of AHSS & PHS with Al and with adhesives.

• Thermal Integrated joining corrosion mitigation study.

• Other Advanced laser-assisted mechanical joining:
  − Development of Thermal Integrated Self Pierce Rivet process.
For More Information

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