Drawn Arc Welding of Fasteners to Advanced High Strength Steels

Dr. Siva Ramasamy
Emhart Teknologies
The author would like to acknowledge the co-authors for this study

Bipin Patel
DaimlerChrysler Corporation
&
Richard Chinoski
Emhart Teknologies
To Assess Weldability and Develop Weld Lobe of Common Automotive Studs and Nuts welded to Advanced High Strength Steels by Drawn Arc Welding Process
1. Determine the feasibility of welding of various fasteners to different base materials
   - CRS-Galvanneal-1.1 mm
   - DP 980-Galvanneal-1.0 mm
   - HSB-Aluminized Silicon-1.25 mm

2. Develop weld lobe for the particular fastener/material combination

3. Quantify weld strength at optimum weld schedule using tensile test method
Type of Fasteners

- **A**: M6 Standard Stud
  - 7 mm Weld Head
  - Zinc Coated
  - Standard Thread

- **B**: M6 Large Flange stud
  - 9 mm weld head
  - Copper Coated
  - Standard thread
  - 1 mm stand-off

- **C**: M6 Large Flange stud
  - 7 mm weld head
  - Zinc trivalent chrome
  - Coated paint cutting thread
  - 2.2 mm stand-off

- **D**: M6 Stud/Nut Stud
  - Zinc-Nickel
  - Coated

- **E**: M6 Nut
  - Zinc trivalent chrome
  - Coated
Drawn Arc Testing Equipment

- Welder Controller
- Feeding System
- Linear Motor Weld Head
The stud is fed into a collet in a weld head or weld gun and the unit is cycled forward until the stud touches the base material generating a STUD ON WORK signal.

The stud lifts a programmable distance from the work surface and a pilot arc is generated. The pilot arc ionizes the air gap between the bottom of the stud and the work surface.

At some predetermined time the main welding current is turned on. The welding current generates molten material at the bottom of the stud and at the surface of the base material.

The weld head then cycles forward plunging the stud into the molten puddle of material. The molten puddle solidifies and the weld head cycles back leaving the welded stud in place.

45 - 100ms
Select an initial set of weld parameters based upon similar materials.

Adjust the welding parameters to improve the welds.

Develop a robust weld lobe based upon 50-ampere & 5-msec increments.

Is the lobe at least 150 amperes by 15 msec?

Can the parameters be further adjusted?

Is there at least a 50 ampere by 5 msec “Acceptable” clearance on all sides?

Yes

Test ended.

Proceed to Weldability testing.

No

No

No
Bend and Pull Test For Stud Welding
### Acceptance Criteria

<table>
<thead>
<tr>
<th>Weld Nugget Size</th>
<th>Preferred</th>
<th>Acceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stud Broke</td>
<td>6</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>2</td>
<td>M</td>
</tr>
<tr>
<td>Preferred Range</td>
<td>100% - 91%</td>
<td>80% - 71%</td>
<td>70% - 61%</td>
</tr>
<tr>
<td>Unacceptable Range</td>
<td>90% - 81%</td>
<td>60% - 0%</td>
<td>60% - 0%</td>
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<tr>
<td>Stud Broke</td>
<td>100% - 91%</td>
<td>80% - 71%</td>
<td>70% - 61%</td>
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<td>Acceptable Range</td>
<td>90% - 81%</td>
<td>60% - 0%</td>
<td>60% - 0%</td>
</tr>
<tr>
<td>Unacceptable Range</td>
<td>60% - 0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Preferred**: 6 stud broke, 5, 4
- **Acceptable**: 3, 2
- **Unacceptable**: 2, 1

*(Important when Weld Size = 6)*
Weld Lobe Development

• Drawn arc welding process exhibits a fairly wide flexibility in welding current and weld time combinations that result in the production of satisfactory welds.

• The cutoff relationship between welding energy input and the weld integrity is difficult to precisely define. This is because there is a broad range of welding current and welding time at which quality welds were obtained, and within this broad range there are settings at which weld quality will be consistent.
Weld Lobe Development

AUTO STEEL PARTNERSHIP - DRAWN-ARC WELDING STUDY 2006

FASTENER DESCRIPTION:
- M6 Stud/Nut
- Zinc-Nickel

FASTENER PLATING:
- 39050
- DP980

EMHART FASTENER PART:
- Galvanize

BASE MATERIAL TYPE:
- 1.0 mm

BASE MATERIAL PLATING:

BASE MATERIAL THICKNESS:

EQUIPMENT:
- DCE 1500 WELD CONTROL
- ETF12 FEEDER
- LM WELD HEAD

WELD PROGRAMMING PARAMETERS:
- LIFT: 1.20mm
- PENETRATION: -1.8 mm
- START DELAY: 250ms
- Taur PILOT LIMIT: 15.0V to 33.0V
- Taur WELD LIMIT: 15.0V to 33.0V
- WELD TIME: +/- 6ms
- WELD CURRENT: +/- 30Amps
- STUD NEGATIVE POLARITY

WELD CURRENT (I) in Amps

WELD TIME (t) in milliseconds

www.autosteel.org
Nut Welding on HSB

Fracture acceptance criteria
Large Flange Stud Welding to HSB

AUTO STEEL PARTNERSHIP - DRAWN-ARC WELDING STUDY 2006

FASTENER DESCRIPTION
FASTENER FABRICATION
EMHART FASTENER PARTS
BASE MATERIAL PLATING
BRONT MATERIAL THICKNESS

ME Large Flange Stud (3 mm head) Class 8.8
Cooper
20056
UMBER HSB
1.25 mm

WELD PROGRAMMING PARAMETERS
LIFT 1.25mm
PENETRATION 1.0 mm
START DELAY 200ms
VAR WELD LIMIT 16.0V to 20.0V
VAR WELD LIMIT 16.0V to 30.0V
WELD TIME 5.0ms
WELD CURRENT 50.0Amp
STUD NEGATIVE POLARITY

EQUIPMENT
DCE 1300 WELD CONTROL
TCP 1310 DEDGER
LM WELD HEAD

AUTO STEEL PARTNERSHIP - DRAWN-ARC WELDING STUDY 2006

FASTENER DESCRIPTION
FASTENER FABRICATION
EMHART FASTENER PARTS
BASE MATERIAL PLATING
BRONT MATERIAL THICKNESS

ME Large Flange Stud (7 mm head) Paint coating thread
20515
UMBER HSB
1.25 mm

WELD PROGRAMMING PARAMETERS
LIFT 1.25mm
PENETRATION 1.0 mm
START DELAY 250ms
VAR WELD LIMIT 16.0V to 20.0V
VAR WELD LIMIT 16.0V to 30.0V
WELD TIME 5.0ms
WELD CURRENT 50.0Amp
STUD NEGATIVE POLARITY

www.autosteel.org
Large Flange Stud Welding to Coated HSB

M6 Large Stud with standard stand-off

M6 Large Stud with higher stand-off
Large Flange Stud Welding to Uncoated HSB

M6 Large Stud with standard stand-off

M6 Large Stud with higher stand-off
## Weld Strength Data

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Base metal type</th>
<th>Base metal thickness (mm)</th>
<th>Fastener Type</th>
<th>Average Pull Strength (lbs)</th>
<th>Fracture Mode</th>
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<tbody>
<tr>
<td>1</td>
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<td>2655</td>
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<td>15</td>
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<td>1.25</td>
<td>M6 Zn LF</td>
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<td>Base metal</td>
</tr>
</tbody>
</table>
Conclusions

Based on the results obtained from this study, the following conclusions can be drawn:

• The fasteners chosen for this study can be welded to the galvannealed coated cold rolled mild steel, galvannealed coated dual phase 980 steel, and aluminum silicon coated hot stamped boron steel.

• Large Flange Stud with the higher standoff is recommended for welding to Hot Stamped Boron Steel.

• For this study the fracture mode for stud welding was in the base material.

• The fracture mode for the M6 nut welding on Hot Stamped Boron Steel was partial base material.
Acknowledgements

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For more information: www.a-sp.org
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