Weld Quality Study of Projection Nut Welding with Modular Weld Head

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Outline

- Introduction
- Modular weld head
- Weld quality study
  - Microstructure
  - Mechanical properties
  - Electrode life
- Closing Remarks
Resistance projection nut welding is widely used in automotive component assembly.

The quality of the joining of these nuts to the stamped body components is critical for the final product's safety and reliability.

The current flow of projection welding is determined by the contact projections.
Welding Electrodes

Backup electrode

Upper electrode

Regular weld head

Quick release
Modular weld head

Lower electrode
Quick Release Modular Weld Head

Disassembled parts of patent-pending quick release modular weld head

* Patent Pending
Modular Weld Head

Disassembled parts of modular weld head
## Cost Analysis

### Regular Head
- Replace whole head at the end of electrode life
- Manufacturing process involves joining of tungsten copper to the copper base
- Approximate electrode life: 10,000

<table>
<thead>
<tr>
<th>Details</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weld surface can be re-surfaced, up to 2 times</td>
<td>$700</td>
</tr>
<tr>
<td>Capital cost and set up cost for re-surfacing</td>
<td>$700</td>
</tr>
<tr>
<td>Electrode height changed after re-surfacing</td>
<td>$700</td>
</tr>
<tr>
<td>Position setup or adding copper shims required</td>
<td>$700</td>
</tr>
</tbody>
</table>

For 600,000 welds:
- Need 20 weld heads = $700
- Re-surface each head 2 times (Total 40 times)
- 40 hours labor for re-surface and set up @ $75/hour

**Total is $3,700**

## Modular Head
- Replace the washer at the end of electrode life
- Individual parts are mechanically assembled
- Approximate electrode life: 10,000

<table>
<thead>
<tr>
<th>Details</th>
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</tr>
</thead>
<tbody>
<tr>
<td>No need to resurface the washer</td>
<td>$0</td>
</tr>
<tr>
<td>Electrode height will always be the same</td>
<td>$0</td>
</tr>
</tbody>
</table>

For 600,000 welds:
- Need 60 washers = $360
- Need 30 liners = $195
- Need 6 nuts = $192
- Need 3 bases = $108

**Total is $855**

## Quick-Release Modular Head
- Replace the washer at the end of electrode life
- Individual parts are mechanically assembled
- Approximate electrode life: 10,000

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</tr>
<tr>
<td>Electrode height will always be the same</td>
<td>$0</td>
</tr>
</tbody>
</table>

For 600,000 welds:
- Need 60 washers = $360
- Need 30 liners = $195
- Need 1 nuts = $75
- Need 1 base = $50

**Total is $680**
Material Properties

<table>
<thead>
<tr>
<th>Weld head</th>
<th>Weld face material</th>
<th>Hardness</th>
<th>Electrical conductivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular Head</td>
<td>Tungsten copper class 11 ELKONITE</td>
<td>HRB 98</td>
<td>45% IACS</td>
</tr>
<tr>
<td>Modular Head</td>
<td>Class 3 copper C18000</td>
<td>HRB 94</td>
<td>48% IACS min</td>
</tr>
</tbody>
</table>

Material properties of weld faces

**Weld Sheet:** 1mm thick GI coated DP600

**Weld Nut:** 3-projection hex-flanged M6 weld nuts

**Welding Machine:** 250 kVA, 60Hz single phase AC RSW machine
Microstructure

Optical microscope images of the projection welds after etching

(a) with regular head

(b) with modular head

Optical microscope images of the projection welds after etching
Hardness Test

Microhardness of the projection welded sample with different weld heads

- Regular Head
- Modular Head

Sheet, Fusion Zone, Nut

Distance to weld sheet bottom (μm)

Hardness (HV0.5)

32kA
Hardness Test

Microhardness of the projection welded sample with different weld heads

26kA

30kA
Tensile Testing

Variation of fracture load with weld current
Fracture Surface

Fracture surface of the projection welds

With regular head

<table>
<thead>
<tr>
<th>Element</th>
<th>Fe</th>
<th>Mn</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot 1</td>
<td>95.84</td>
<td>1.32</td>
<td>2.83</td>
</tr>
<tr>
<td>Spot 2</td>
<td>92.70</td>
<td>1.08</td>
<td>6.22</td>
</tr>
<tr>
<td>Spot 3</td>
<td>2.34</td>
<td>-</td>
<td>97.66</td>
</tr>
</tbody>
</table>

EDX results

With modular head
Fracture Surface

(a) with regular head  (b) with modular head

High magnification SEM images of the fracture surface
Electrode Life for Projection Nut Welding

There are no standards, or references about electrode life test for projection nut welding by now

Approaches to evaluating electrode life

➢ Tensile test
➢ Weld thickness
➢ Weld hardness
➢ Torque
Electrode Life – Fracture Load

Variation of weld thickness difference between regular head and modular head
Electrode Life – Weld Thickness

Variation of weld thickness difference between regular head and modular head
Electrode Life – Weld Hardness

**Regular Head**

**Quick Release Head**

Distance from bottom of sheet

Hardness HV 0.5

Distance from bottom of sheet

Hardness HV 0.5

- 0
- 2000
- 3000
- 4000
- 5000

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Electrode Life – Torque

TWI Guidelines:

<table>
<thead>
<tr>
<th>Nut size</th>
<th>Electrode force, kN</th>
<th>Weld time, cycles</th>
<th>Approximate welding current, kA</th>
<th>Typical minimum torque to failure, Nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>M5</td>
<td>3.6</td>
<td>5</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>M6</td>
<td>4.2</td>
<td>6</td>
<td>10.5</td>
<td>20</td>
</tr>
<tr>
<td>M8</td>
<td>4.9</td>
<td>9</td>
<td>17</td>
<td>50</td>
</tr>
</tbody>
</table>
Electrode Life – Wear of Weld Face

Tungsten copper weld face on regular head weld
5,000 weld
Electrode Life – Wear of Weld Face

Class 3 copper weld face on modular head weld

5,000 weld
Both weld heads produced good quality welds between the nut and DP600 steel sheet.

The welds created with a modular head exhibited a slightly thinner heat affected zone due to the better conductivity of the Class 3 copper weld face.

Tensile testing results indicate that the welds made with both heads had very similar ultimate. The fracture surface from both welds exhibited a ductile fracture mode.

The life test results indicate that the overall weld life of both weld head types was found to be similar.
Thanks