Resistance Microwelding Best Practices in Braze Set-Up Operations

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Aimtek Background

- Founded in 1973 in Worcester, MA USA
- Independently (Family) Owned and Operated
- Value-Added Manufacturer and Global Supplier of Brazing Alloys, Welding Alloys, and Thermal Spray Products
- North American Distributor for Soudax Equipements (France)
- Global Distribution and Representation Network
- Primary Industries Served: Aerospace, Industrial Gas Turbine, Automotive, Defense, Semiconductor
- 2-time Region I Small Business of the Year
- 3-time Pratt & Whitney Small Business Supplier of the Year
- AS9100/ISO9001 Registered Quality System
- UTC Supplier Gold since 2010
- All Major Aerospace OEM Qualifications
• Ball Tack Welding
• Poke Tack Welding
• Honeycomb Tack Welding
Joule’s First Law:  \( P = I^2R(t) \)

- \( P = \) Power (Energy per unit time)
- \( I = \) Current (welding current)
- \( R = \) Resistance (ohms)
- \( t = \) time (milliseconds)
# Selected Properties of Common Materials

<table>
<thead>
<tr>
<th>Metal</th>
<th>Thermal Conductivity (W/mK) 20°C</th>
<th>Melting Point (°C)</th>
<th>Electrical Resistivity (x 10⁻⁸ Ωm) 20°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>223</td>
<td>1084</td>
<td>1.724</td>
</tr>
<tr>
<td>Aluminum</td>
<td>118</td>
<td>660</td>
<td>2.65</td>
</tr>
<tr>
<td>Zinc</td>
<td>67</td>
<td>419</td>
<td>5.92</td>
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<tr>
<td>Iron</td>
<td>42</td>
<td>1482</td>
<td>9.71</td>
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<tr>
<td>Stainless Steel</td>
<td>17-26</td>
<td>1455</td>
<td>69</td>
</tr>
<tr>
<td>Inconel</td>
<td>8-9</td>
<td>1350</td>
<td>129</td>
</tr>
<tr>
<td>Hastelloy</td>
<td>5-6</td>
<td>1355</td>
<td>118</td>
</tr>
</tbody>
</table>

*Values from various industry sources*
Power Supplies and Processes

Capacitor Discharge
- Ball Tacking
- Poke Tacking

Inverter
- Ball Tacking
- Poke Tacking
- Honeycomb Tacking
- Integration with Sensors
- Automation

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Types of Current Waveforms

Illustration from Soudax Equipements

Single phase AC
Capacitor Discharge
3 phase DC
MFDC (Inverter)
Ball Tack Welding

**Purpose:** To properly position details prior to brazing
Ball Tack Welding

Typical Equipment:

- Capacitor discharge or Inverter power supply
- Vacuum welding pen and pump
- Tacking balls – any metallic material
- Grounding fixture
Solid State Bond - In a Solid State Bond (also called thermo-compression Bond), dissimilar materials with dissimilar grain structure, e.g. molybdenum to tungsten, are joined using a very short heating time, high weld energy, and high force. There is little melting and minimum grain growth, but a definite bond and grain interface. Thus the materials actually bond while still in the “solid state.” The bonded materials typically exhibit excellent shear and tensile strength, but poor peel strength.

Fusion Bond - In a Fusion Bond, either similar or dissimilar materials with similar grain structures are heated to the melting point (liquid state) of both. The subsequent cooling and combination of the materials forms a “nugget” alloy of the two materials with larger grain growth. Typically, high weld energies at either short or long weld times, depending on physical characteristics, are used to produce fusion bonds. The bonded materials usually exhibit excellent tensile, peel and shear strengths.
Ball Tack Welding Common Applications

Tubes and Manifolds
Ball Tack Welding Common Applications

Vanes
Ball Tack Welding Common Applications

Photos from Soudax Equipements

LPT Nozzle Assembly Sleeve and Air Duct
Ball Tack Welding Best Practices

- Ball material compatible with base materials (304L, 410, 625, X, CP-Ti)
- Minimum ball size that will hold parts (0.5 to 2.0mm diameter)
- Return current (ground) fixture close to welding position
- Good contact on mating surfaces
- Short to Medium discharge time
Ball Tack Welding Best Practices

Grounding

Electrode selection

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Ball Tack SEM After Brazing
Poke Tack Welding

**Purpose:** To attach foil preforms or tack thin segments
Typical Equipment:

- Capacitor discharge or Inverter power supply
- Welding hand tools or head
- Electrodes
- Grounding fixture
Poke Tack Welding Common Applications

Presintered Braze Preforms (PSP)  
Foil Preforms
Poke Tack Welding Best Practices

- Electrode configuration compatible with part geometry
- Identify electrical resistivity
- Minimum current to secure part
- Return current (ground) fixture close to welding position
- Good contact on mating surfaces
- Short discharge time
Honeycomb Tack Welding

**Purpose:** To properly position honeycomb segment prior to brazing
Typical Equipment:

- Inverter power supply
- Pneumatic welding head
- Copper electrode
- Grounding fixture
**Preparation:**

- Verify honeycomb geometry
- Transfer tape (BFM) is properly placed and pressed onto the honeycomb
- Honeycomb contact surface scraped to reveal the bottom edges for subsequent resistance welding

*Photos from Dan Kay*
Preparation (con’t)

Preloaded honeycomb can be inconsistent
Preparation (con’t)

• Identify cell size
• Parameter development
• Electrode and fixture design
Honeycomb Tack Welding
Best Practices – Parameter Development

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<tr>
<th>P/N</th>
<th>Height</th>
<th>Width</th>
<th>Cell Size</th>
<th>Electrode Size</th>
<th>Docking</th>
<th>Squeezing</th>
<th>Force</th>
<th>Ramp</th>
<th>Flat</th>
<th>Forging</th>
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<tr>
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<td>8</td>
<td>32</td>
<td>1.6</td>
<td>25 x 32</td>
<td>100ms</td>
<td>200ms</td>
<td>50%</td>
<td>3ms</td>
<td>35% @ 3ms</td>
<td>100ms</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>25</td>
<td>0.8</td>
<td>25 x 25</td>
<td>100ms</td>
<td>200ms</td>
<td>40%</td>
<td>4ms</td>
<td>40% @ 3ms</td>
<td>100ms</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>25</td>
<td>0.8</td>
<td>24 x 24</td>
<td>100ms</td>
<td>200ms</td>
<td>40%</td>
<td>4ms</td>
<td>40% @ 3ms</td>
<td>100ms</td>
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<tr>
<td>4</td>
<td>4</td>
<td>25</td>
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<td>25 x 25</td>
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<td>200ms</td>
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<td>4ms</td>
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</tr>
<tr>
<td>5</td>
<td>7</td>
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<td>1.6</td>
<td>25 x 31</td>
<td>100ms</td>
<td>200ms</td>
<td>40%</td>
<td>3ms</td>
<td>35% @ 3ms</td>
<td>100ms</td>
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<tr>
<td>6</td>
<td>8.5</td>
<td>46</td>
<td>0.8</td>
<td>25 x 46</td>
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<td>200ms</td>
<td>50%</td>
<td>4ms</td>
<td>50% @ 3ms</td>
<td>100ms</td>
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</tbody>
</table>
Honeycomb Tack Welding
Best Practices – Electrode Design

Copper Braid
Conductive Silicone Ag/Cu
Poor Electrode Design

Excessive Burning

Excessive Force - deformation
Additional Best Practices:
It is necessary to make sufficient spot welds (across the full width of the honeycomb and in ring seals along the honeycomb edges) to ensure that the honeycomb remains in intimate contact with the backing support throughout the entire brazing cycle. It usually is necessary to test the proper degree of overlapping needed, based on the spot weld electrode used.

For consistent resistance welded honeycomb structures, proper electrode amperage and force settings, once developed, should be in written procedures, controlled and monitored. This can help prevent arcing, flashing, sparks, and burns holes in the honeycomb and possible crushing of the honeycomb at the weld interface.
Processes Can Be Automated!

Collaborative Robot

Turnkey Cell
Please visit our website for more information and videos:

www.aimtek.com