**WHAT IS ULTRASONIC CONSOLIDATION?**

- Ultrasonic Consolidation (UC) is a solid-state processing technique that can be used to weld metal foils together.
- Using a foil-fiber-foil method or prepreg tapes, metal matrix composite (MMC) structures can be fabricated through a layered build-up process similar to tape placement for thermoplastic composites.
- Advantages over other traditional MMC processing methods:
  - Low processing temperatures minimize residual stresses in the material and changes in the microstructure
  - Ability to weld dissimilar materials
  - Fast production times

**PROCESSING TECHNIQUE**

- Metal foils or prepreg tapes are placed on top of a stationary anvil and a rotating horn travels the length of the foils.
- Three machine variables are used during the processing and influence the resulting bond between foils:
  - Applied normal force or load
  - Oscillation amplitude
  - Welding speed

**POTENTIAL BONDING MECHANISMS**

- Removal of surface oxide layer between foils through oscillating and normal forces
- Formation of bonds across the interface

<table>
<thead>
<tr>
<th>Possible Mechanisms</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic Deformation</td>
<td>Metal matrix flow caused by dislocation movement</td>
</tr>
<tr>
<td>Diffusion</td>
<td>Transfer of mass across an interface</td>
</tr>
<tr>
<td>Acoustic Softening</td>
<td>Ultrasonic energy causes a reduction of stress for plastic deformation</td>
</tr>
<tr>
<td>Mechanical Interlocking</td>
<td>Metal flows into irregularities and locks mechanically</td>
</tr>
<tr>
<td>Interfacial Melting</td>
<td>Molten metal flow at the interface</td>
</tr>
<tr>
<td>Atomic Attraction</td>
<td>Materials brought within atomic distances are attracted to each other</td>
</tr>
</tbody>
</table>

**MECHANICAL TESTS FOR BOND QUALITY**

- Previous studies have shown that bond strength can exceed the tensile strength of the base metal
- Tensile failure occurs within a single foil rather than the weld interface
- Lap-shear tests with fiber reinforced MMC tapes are currently being explored as a viable technique to measure shear strength of ultrasonically consolidated tapes

**MICROSCOPY OF WELD INTERFACE**

- Optical microscopy shows full consolidation of UC MetPreg™ tapes (alumina fiber reinforced aluminum matrix prepreg manufactured by Touchstone Research Laboratory)

**SURFACE ROUGHNESS**

- Impressions from the knurl pattern on the horn
- These impressions increase the surface roughness of the tapes, which will impact friction and heat generation for welding additional layers

**FUTURE WORK**

- Find processing window for optimal shear strength using design of experiments and lap-shear testing
- Further investigate and explore bonding mechanisms
- Determine if full consolidation occurs in multi-layer composites

**ACKNOWLEDGEMENTS**

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