A PRELIMINARY STUDY OF DOUBLE-SIDED ARC WELDING PROCESS IN SHIP STRUCTURE MANUFACTURING

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Sponsor: NSRP SP-7

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Objective

- Determine the feasibility of double-sided arc welding process in butt welding of DH-36 plates
Double-sided arc welding (DSAW): a novel arc welding process developed at the University of Kentucky with a grant from National Science Foundation.

Major Advantages of DSAW: deep narrow penetration, symmetrical heat input & weld bead shape, and minimized distortion.
Background: A Previous Study

- Weld 3/8 inch DH36 Plates@UK
- Evaluation: Warren Mayott@EB

  Welding Position: Vertical-down
  Welding Speed: 120 mm/min (4.7 inch/min)
  Peak Current: 140 A
  Base Current: 80 A
  Filler Metal: no
## Previous Study

### Hardness

<table>
<thead>
<tr>
<th>Location</th>
<th>HVN</th>
<th>HR&lt;sub&gt;C&lt;/sub&gt;</th>
<th>HR&lt;sub&gt;B&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Material</td>
<td>174</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>Fine Grain HAZ</td>
<td>196</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>Large Grain HAZ</td>
<td>227</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>Weld Metal</td>
<td>279</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Large Grain HAZ</td>
<td>233</td>
<td>96</td>
<td></td>
</tr>
</tbody>
</table>
### Transverse Tensile Test

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>Tensile Strength (PSI)</th>
<th>Break Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>82,000</td>
<td>Broke About 1-1/2” From Weld Centerline</td>
</tr>
<tr>
<td>2</td>
<td>83,000</td>
<td>Broke About 1-1/2” From Weld Centerline</td>
</tr>
</tbody>
</table>

### Transverse Bend Test

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>Bend Results (180° Bend, ½” Bend Radius)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acceptable-1 Void 1/32” diameter; 1 Void 1/64” diameter</td>
</tr>
<tr>
<td>2</td>
<td>1 Void 5/64” diameter (Present before bending)</td>
</tr>
</tbody>
</table>
### Previous Study

#### Toughness Values
(Subsize Charpy V Notch {0.394” x 0.197”})
Test Temperature: -4°F

<table>
<thead>
<tr>
<th>Location</th>
<th>Charpy Value</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Material</td>
<td>25 Ft. lbs. (11 Ft. lbs. Minimum Required By Spec for subsize)</td>
<td>Notch Parallel to Rolling Direction</td>
</tr>
<tr>
<td>Weld</td>
<td>3 Ft. lbs.</td>
<td>&lt;5 Ft. lbs. – Info Only</td>
</tr>
<tr>
<td>.030” from fusion line into HAZ</td>
<td>5 Ft. lbs.</td>
<td>Notch Parallel to Rolling Direction</td>
</tr>
<tr>
<td>.125” from fusion line into HAZ</td>
<td>7 Ft. lbs.</td>
<td>Notch Parallel to Rolling Direction</td>
</tr>
</tbody>
</table>
NSRP SP-7 Panel Project: New System

- New System: one torch moving only
- Previous System: two torches moving simultaneously
New System: Why Possible?
Arc-Following
Control Principle

No Additional Sensor!
Task One: All Positions Possible?

Flat Position
Filler: no

Horizontal Position
Filler: no

Vertical-down Position
Filler: pre-deposited
Task One: All Positions Possible?

Toughness: no significant improvement!

⇒ Filler Metal Is Needed!
Task Two: Filler Metal Addition

- **Position:** Vertical-Down
- **Gap:** 0.06” (1.5 mm)
- **Filler Metal:** 0.035” ER-70S-3@80 in/min
Task Two: Filler Metal Addition

Position: Flat
Gap: 0.1” (2.5 mm)
Filler Metal: 0.045” ER-70S-3 @90 in/min
Task Two: Filler Metal Addition

Toughness: no significant improvement!
→ Can you use another filler metal?
## Task Three: Inconel 625 Filler Metal

### Toughness Values
(3/4 Subsize)

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Test Temp (F)</th>
<th>Energy Absorbed (ft-lbs)</th>
<th>Converted</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>-4</td>
<td>40</td>
<td>51.75</td>
</tr>
<tr>
<td>02</td>
<td>-4</td>
<td>45</td>
<td>58.21</td>
</tr>
<tr>
<td>03</td>
<td>-4</td>
<td>39</td>
<td>50.45</td>
</tr>
<tr>
<td>04</td>
<td>75</td>
<td>42</td>
<td>54.33</td>
</tr>
<tr>
<td>05</td>
<td>75</td>
<td>46</td>
<td>59.51</td>
</tr>
</tbody>
</table>
Task Three: Inconel 625 Filler Metal

Microhardness Traverse Across Butt Joint of DSAW Weld. Base Metal - DH-36. Filler Metal - INCONEL 625
What to Do Next?

- Complete testing of Inconel 625
  - Tensile tests
  - HAZ toughness
  - Bend tests
- Improvement of Control System: the same scheme for all positions, different/varying gaps
Future Development Work

- Evaluate other nickel bearing filler materials
- Develop the parameters for optimal speed: power supply required
- Improvement of shielding
- Recording of flow rates of all gases
Acknowledgment of Funding Sources

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