Title: Ion-Nitriding after Welding Improves SCC (Stress Corrosion Cracking) Resistance of Stainless Steel Weldments

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Ion-Nitriding after Welding Improves SCC (Stress Corrosion Cracking) Resistance of Stainless Steel Weldments†

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KEY WORDS: (Stress Corrosion Cracking) (Weldment) (Stainless Steel) (Ion-Nitriding)

Weldments of stainless steel tubes are much crack susceptible for SCC (stress corrosion cracking) in general. This short note is concerned in an improvement for SCC resistance of weldments of SUS 304 stainless steel tubes using the technique of the surface nitriding treatment1). The experimental results showed much improvement for SCC resistance in the weldment by this treatment.

The tubes used are SUS 304TB (C: 0.04, Si: 0.52, Mn: 1.51, P: 0.028, S: 0.001, Ni: 9.35, Cr: 18.50%, ō₇₅: 31 and σ₀₅: 63 kgf/mm², El: 80%) with 60.5 mmØ OD and 8.7 mm thick. The shape of weld test specimen was shown in Fig. 1 and welding variables used was shown in Table 1. Welding was completed with 4 layers with 7 passes.

Table 1 Welding parameter for SUS 304 TB tube joint (filler wire Y308L)

<table>
<thead>
<tr>
<th>Layer</th>
<th>Pass No.</th>
<th>Welding process</th>
<th>Current (A)</th>
<th>Voltage (V)</th>
<th>Speed (mm/min)</th>
<th>Heat input (KJ/cm)</th>
<th>Interpass temp. (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Manual GTA</td>
<td>120</td>
<td>10.2</td>
<td>75</td>
<td>9.8</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Automatic GTA</td>
<td>*100-115</td>
<td>9.5</td>
<td>66</td>
<td>9.3</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Automatic GTA</td>
<td>*100-115</td>
<td>9.5</td>
<td>66</td>
<td>9.3</td>
<td>45</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>Automatic GTA</td>
<td>*107-135</td>
<td>9.5</td>
<td>63</td>
<td>10.9</td>
<td>44</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>Automatic GTA</td>
<td>*107-135</td>
<td>9.5</td>
<td>63</td>
<td>10.9</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Automatic GTA</td>
<td>*100-125</td>
<td>9.5</td>
<td>65</td>
<td>9.9</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Automatic GTA</td>
<td>*100-125</td>
<td>9.5</td>
<td>65</td>
<td>9.9</td>
<td>84</td>
</tr>
</tbody>
</table>

* Base and peak current for lower and higher current respectively.

After welding the specimens were ion-treated with N₂-H₂ gas for nitriding1) or argon gas for various temperatures. Then the specimens were treated for SCC resistance comparing with as-welded specimens. The SCC test was done in immersion type in a boiling 42%MgCl₂ solution for max. 20 hrs.

Table 2 showed the condition for ion-treatment after welding and the results of cracking after SCC tests. Cracks in mark x were observed only on inner surface in HAZ of the tube joint. Figure 2(a) and (b) showed typical macroviews of inner surface of welded tubes with many SCC-cracks in HAZ in as-welded condition and noncracked in ion-nitriding treated specimens higher than 550°C after SCC test, respectively.

As shown in Table 2 SCC-cracks were observed as-welded, 400°C ion-nitrided, and 400°C and 750°C argon

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185
(a) Cracked surface after 1 hr test (As-welded specimen)

550°C, 3 hrs

750°C, 3 hrs

850°C, 3 hrs

1100°C, 3 hrs

(b) Noncracked surfaces after 20 hrs test (Ion-nitried specimen)

Fig. 2 Macrosopic pictures of inner surface of tube specimens after SCC test
ion-treated specimens, while there was no crack in the specimens which were nitrided with 550, 750, 850 and 1100°C, 3 hrs. Treatment in argon atmosphere showed no improvement for SCC resistance.

The treated specimens with nitriding higher than 550°C showed hardened and nitride layers in both surfaces of the test tubes. There was no any layer, of course, in the specimens treated in argon atmosphere.

In conclusion remarks in this note the welded tube specimens of austenitic stainless steel are much improved for SCC resistance in boiling 42%MgCl₂ solution when ion-nitriding treatment is done for temperature higher than 550°C after welding. However, argon ion-treatment didn’t show any beneficial effect for SCC resistance of the welded joint even if treating temperature is elevated as 750°C.

The reason why the SCC resistance is so improved by ion-nitriding technique is not confirmed at the present but is considered due to both beneficial effects of the reduction of residual stress of the weldment by nitriding and the protective coating of nitride layer on the surfaces.

Reference