Hydrogen Absorption Capability of High Strength Weld Wire and Weld Metal for Line Pipe

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ABSTRACT
The hydrogen absorption capability of high-strength weld wire and weld metal with 1000 MPa for line pipes was investigated in order to prevent the cold-cracking of high-strength weld metal for line pipes by applying hydrogen traps to high-strength weld metal. Hydrogen concentration immediately after cathodic-charging and that after holding for 72 hours at 45°C indicated the maximum value at the tempering temperature of weld wire at 600°C. Especially, the hydrogen concentration after holding for 72 hours at 45°C indicated 2 ppm at the tempering temperature of the weld wire at 600°C. A hydrogen trap site was identified with molybdenum and chromium carbide from Transmission Electron Microscope (TEM) observation and Electron Dispersive Spectroscopy (EDS) analysis because the maximum hardness indicated the maximum value at the tempering temperature of the weld wire at 600°C. The hydrogen concentration due to hydrogen traps was confirmed in the high-strength weld metal for line pipes.

KEYWORDS: Hydrogen trap, high-strength weld metal, cold-cracking, line pipes, precipitates, molybdenum and chromium carbide

INTRODUCTION
It is well known that cold-cracking sometimes occurs in high-strength weld metal for line pipes. In order to prevent cold-cracking, it is very effective to reduce the strength of the weld metal and to perform the pre-heating or post-heating of the weld metal. However, a decrease in strength is very difficult to achieve when over-matching with the base metal. Moreover, it is not cost effective to perform the pre-heating or post-heating of the weld metal. Therefore, the effect of tempering temperature on the hydrogen concentration of the weld wire and weld metal of double-submerged arc welding (DSAW) immediately after cathodic-charging and after the evolution of diffused hydrogen holding at 45°C for 72 hours was investigated in detail.

EXPERIMENTAL PROCEDURE

Material
High-strength weld wire with a 4-mm outside diameter for high-strength steel was used for this study. The chemical composition of the weld wire consisted of low carbon, high manganese, molybdenum, chromium, and nickel. This wire was solution-treated at 1300°C for 30 minutes and tempered from 250°C to 700°C.

Welding
DSAW was conducted using high-strength plates and high-strength weld wire. The chemical composition of the high-strength plate was 0.04C-1.9Mn-0.3Mo-Nb-Ti-B steel (Asahi and Hara, 2003; Asahi and Tsuru, 2003). Table 1 shows the chemical compositions of the high-strength plates and weld metal. The hydrogen concentration inside the weld metal after holding for 72 hours at 45°C for DSAW was measured using Thermal Desorption Spectroscopy (TDS) analysis, in order to clarify whether a hydrogen trap site existed or not.

<table>
<thead>
<tr>
<th>Base Metal</th>
<th>C</th>
<th>Mn</th>
<th>Mo</th>
<th>Ti</th>
<th>B</th>
<th>Others</th>
<th>Pcm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weld Metal</td>
<td>0.04</td>
<td>1.9</td>
<td>0.3</td>
<td>0.01</td>
<td>0.001</td>
<td>others</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Cathodic-charging Measurement
Galvanostatic-charging was carried out. The test solution was 3 mass% NaCl and 3 g/L of NH₄SCN. The applied current densities were selected as 1.1 mA/cm² (11 A/m²). The charging time was 100 hours.

Hydrogen concentration immediately after galvanostatic-charging and that holding at 45°C for 72 hours after galvanostatic-charging was