**CORROSION RESISTANCE OF S355J2 STEEL WELDED BY SAW BEFORE AND AFTER SURFACE TREATMENT BY PHOSPHATING**

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### 1. Introduction

Corrosion resistance is of great importance for the materials usage, particularly for steel. The corrosion resistance depends on an environment where the material is present, on the chemical composition and structure of the material. Resistance to atmospheric corrosion of steel can be increased by addition of a small addition of copper. Addition of Ni is also effective. Increase of atmospheric corrosion resistance can be also reached by sufficient amounts of Cr in a combination with Cu. In general, maximal resistance to atmospheric corrosion can be achieved by a higher content of alloying elements [1, 2].

Submerged arc welding (SAW) is an arc welding process and the arc is shielded by a layer of flux which protects the molten weld metal from atmospheric contamination. The base metal (BM), the heat affected zone (HAZ) and the weld metal (WM) are parts of the welded joint and define the properties of the welded joints and welded constructions [3, 4].

SAW is the most widespread method for welding large diameter pipes because of its elevated productivity. Its main drawback, however, is that very high residual stresses develop around the welded area [5]. This may also influence the corrosion resistance of the weld metal.

### 2. Experiment

S355J2 steel was used as an experimental material with a known chemical composition listed in table 1. The microstructure of the S355J2 steel (Fig. 1) is formed by ferrite-pearlite matrix with a low pearlite content (local pearlite occurrence) and with the grain size of about 10 microns. Fillet welds were made on plates of 250 mm × 500 mm × 30 mm using SAW.

### 3. Results

As can be seen from the measured potentiodynamic curves (Fig. 2) and electrochemical characteristics (Table 2) in 0.1M Na₂SO₄ evaluated by the Tafel analysis, the base material (BM) has higher thermodynamic stability than weld metal (WM), because the value of corrosion potential (E₉ₐ₉₉) is more positive about 41 mV. However, higher kinetic stability
is reached by WM than by BM, representing by lower corrosion current density ($i_{\text{Corr}}$) value and corresponding corrosion rate ($v_{\text{Corr}}$) value.

Fig. 2 Potentiodynamic curves of S355J2 steel

Created phosphate layer has porous nature and homogenous crystalic structure with negligible visual differences on both tested surfaces (BM and WM). By forming a stable mechanical barrier against corrosion mechanisms this layer increased the corrosion resistance of the tested surfaces in 0.1M Na$_2$SO$_4$ environment. Electrochemical corrosion characteristics of the phosphate layer created on BM and WM are very similar as seen in table 1.

<table>
<thead>
<tr>
<th></th>
<th>$E_{\text{Corr}}$ [mV]</th>
<th>$i_{\text{Corr}}$ [µA.cm$^{-2}$]</th>
<th>$v_{\text{Corr}}$ [µm.y$^{-1}$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM</td>
<td>-604 ± 10</td>
<td>20.3 ± 1.5</td>
<td>472 ± 21</td>
</tr>
<tr>
<td>WM</td>
<td>-645 ± 13</td>
<td>14.1 ± 1.9</td>
<td>325 ± 18</td>
</tr>
<tr>
<td>BM + MnP</td>
<td>-592 ± 12</td>
<td>0.086 ± 0.003</td>
<td>1.95 ± 0.1</td>
</tr>
<tr>
<td>WM + MnP</td>
<td>-603 ± 10</td>
<td>0.099 ± 0.005</td>
<td>2.29 ± 0.2</td>
</tr>
</tbody>
</table>

Tab. 2 Electrochemical characteristics of S355J2 steel

The difference between corrosion properties of the surface with and without phosphate layer is mainly in $i_{\text{Corr}}$ and $v_{\text{Corr}}$ values as the corrosion potential (-592 mV resp. -603 mV) of the phosphate layer is similar to values of BM (-604 mV) This means, that forming a phosphate layer results in increase of corrosion resistance through a reduction of the corrosion current density from 20.3 µA.cm$^{-2}$ resp. 14.1 µA.cm$^{-2}$ to 0.086 µA.cm$^{-2}$ resp. 0.099 µA.cm$^{-2}$ and corrosion rate from 472 µm.y$^{-1}$ resp. 325 µm.y$^{-1}$ to 1.95 µm.y$^{-1}$ resp. 2.29 µm.y$^{-1}$.

4. Conclusions
The present work describes the influence of surface treatment by phosphating on corrosion properties of S355J2 steel and welded SAW joint in 0.1M Na$_2$SO$_4$ solution. It may be concluded:

- Tested base material (S355J2 steel) has higher thermodynamic stability than weld metal, which shows higher kinetic stability in 0.1M Na$_2$SO$_4$.
- Corrosion resistance of BM and WM after phosphating is very similar.
- Increased corrosion resistance of phosphate surfaces is reached kinetically by reducing values of $i_{\text{Corr}}$ and $v_{\text{Corr}}$.

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References