THE RESISTANCE OF AISI 316TI STAINLESS STEEL TO PITTING CORROSION WITH VARIOUS TREATED SURFACE

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1. Introduction
The aim of this work is to study the effect of surface treatment of AISI 316Ti stainless steel to pitting corrosion resistance [1]. Austenitic stainless steels are the most common of the multicomponent construction materials used by the chemical, petrochemical, nuclear, food industries and medicine. These steels are selected basically for a good combination of mechanical, fabrication and excellent corrosion resistance properties [2].

2. Surface treatment
The experimentally tested surfaces were mechanically and chemically modified. First set of specimens was blasted with non-metallic particles of almandine. Almandine is the sharp natural garnet. Second set of specimens was blasted with metallic particles of globular metal granules. Both of sets were treated chemically by pickling.

Conditions of surface treatment:
- Pickling - composition of solution: 220 ml of 65% HNO₃ + 22 ml of 40% HF + 758 ml of distilled H₂O, time of 30 min, temperature of 21 ± 1 °C.
- Non - metallic blasting: pressure - 0.4 MPa, jet distance from surface - 220 mm, mean sharp grain size of almandine - 0.15 mm.
- Metallic blasting: pressure - 0.4 MPa, jet distance from surface - 220 mm, mean globular grain size of metallic granules - 0.65 mm.

3. Experimental solutions
The experimental material was subjected to the exposure methods according to the standard ASTM G 48 (for FeCl₃) and ASTM G 46 (for NaCl), the electrochemical properties of AISI 316Ti stainless steel were detected by electrochemical impedance spectroscopy and visually it was evaluated corrosion damage according to the standard ČSN ISO 11 463. Two solution with identical content of chloride ions but with various oxidation potential were used (5% NaCl solution and 4.6% FeCl₃ solution were chosen). Values of redox potential solutions according to the standard DIN 38404 of the experimental solutions are:
- 5% NaCl - 247 mVh
- 4.6% FeCl₃ - 526 mVh

4. Immersion test
The immersion test is carried out in the solution of 4.6% FeCl₃ and 5% NaCl according to the standard ASTM G 48 (for FeCl₃) ASTM G 46 (for NaCl) and ČSN ISO 11463 aimed for evaluation density and size of pits [3].

<table>
<thead>
<tr>
<th>Specimen with different surface treatment</th>
<th>4.6% FeCl₃</th>
<th>5% NaCl</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>corrosion rate [g.m⁻².h⁻¹]</td>
<td>density (A) and size (B) of pits</td>
</tr>
<tr>
<td>BA</td>
<td>9.35142</td>
<td>3A 2B</td>
</tr>
<tr>
<td>BAP</td>
<td>13.28545</td>
<td>4A 2B</td>
</tr>
<tr>
<td>BG</td>
<td>7.53632</td>
<td>2A 2B</td>
</tr>
<tr>
<td>BGP</td>
<td>7.69563</td>
<td>3A 2B</td>
</tr>
</tbody>
</table>

Tab. 1: Corrosion rate and pit density of the AISI 316Ti SS after immersion test
Note: The value of density and size of pits in 5% NaCl solution are missed because evaluation by ČSN ISO 11463 is impossible.

5. Electrochemical impedance spectroscopy (EIS)
The electrochemical tests are performed by using the electrochemical impedance spectroscopy (EIS) in solutions of 5% NaCl and
4.6% FeCl₃ at laboratory temperatures (21 ± 1°C). This method allows establishing the value of polarization resistance of less conductive corrosion systems, for example when a passive layer with good adhesion is created on the metal surface. The polarization resistance ($R_p$) is an electrochemical property characterizing the material resistance to polarization in the experimental environment. The higher value of $R_p$ represents better corrosion resistance of the material in corrosion environment [4].

![Fig. 1](image1) Values of polarization resistance $R_p$ for 4.6% FeCl₃ solution

![Fig. 2](image2) Values of polarization resistance $R_p$ for 5% NaCl solution

6. Conclusion

- In spite of the same concentration of Cl⁻ ions, the 4.6% FeCl₃ solution with a higher redox potential is much more aggressive to the tested steel than the 5% NaCl solution with a lower redox potential. Therefore the pitting corrosion resistance of variously surface treated AISI 316Ti stainless steel in the 4.6% FeCl₃ solution is incomparably lower than in the 5% NaCl solution (corrosion rates in the 4.6% FeCl₃ are 10 to 100 times higher than in the 5% NaCl solution, polarisation resistances $R_p$ in the 4.6% FeCl₃ solution are 1000 times lower than in the 5% NaCl).

- The mechanical treated specimens are more corrosion resistant (higher value of polarization resistance $R_p$) in solution with a higher redox potential (4.6% FeCl₃). In the opposite the chemical treated specimens are more resistant in solution with a lower redox potential (5% NaCl). The corrosion resistance is expressly influenced by mechanism of corrosion.

7. Acknowledgements

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8. References