PROBLEMS POSED BY THE DESIGN AND IMPLEMENTATION OF A WELDED PETROCHEMICAL STORAGE TANK

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Abstract
Storage tanks raises numerous problems, in terms of their design and construction of their practical implementation technology, depending on their shape, size, type and thickness of the components materials, welding technology chosen (sequence of the welding operations control, the technological parameters, etc.), storage medium. The life time of these tanks is dependent of the conditions, operating parameters, how they are kept under control and of the maintenance. Therefore, the materials used to manufacture the storage tanks belong to stainless steel category because of their corrosion resistance which is superior compared to the unalloyed steels. The paper presents technical data and technology of welding material, indicating the sequential order to achieve the storage tank (side walls, shell), based on studies and experience in the field. Attachment welds were made by MMA process 111 (manual metal arc welding). After the welding process was made a strict control during and after the welding process such as: nondestructive testing, visual inspection, Rx control, and tightness control which highlighted the desired quality of the tank connections. The tests of corrosion shows that the stainless steel has a high corrosion resistance, with an efficiency of 92%, compared with non-alloyed steel components tested both in medium sodium chloride and hydrochloric acid.

Keywords: storage tank, stainless steel, microstructure, corrosion tests

1. \textbf{INTRODUCTION}

Storage tanks and vessels contain different liquids, non organic liquids, vapors from diverse domains which are generally installed inside the containment basins in order to contain spills in case of rupture of the tank [1,2]. The storage tanks are used in many industries as: petroleum producing and refining, petrochemical and chemical manufacturing, bulk storage and transfer operations, other industries consuming or producing liquids and Vapors [3,4]. The storage tanks are used for a long time, in conditions and parameters controlled by continuous monitoring [5,6]. The tank is a welded construction made of sheet 6 and 8 mm as follows [7]:
- Bottom of tank and shells that are made up of 6 mm thick sheet
- Reinforcements are made of sheet thickness of 8 mm

2. \textbf{SEQUENTIAL ORDER TO REALIZE THE STORAGE TANK}

Sequential order is presented in figure 1. Respecting with high accuracy every steps it can be avoid the occurrence of stress and strain in the realized joints.
Fig. 1 Sequential order to realize the storage tank
3. MATERIALS USED

Choosing the base material for execution of the storage tank is made in the design phase, according to several criteria: its destination, operating temperature, operating safety, size and environmental characteristics: corrosion, wear, the irradiation process execution technology (welding, etc.).

In the present case it is taken into account the stored substances and the good behavior of these basic materials in corrosive environment. So it was started from two basic types materials: non-alloyed steel (S235JR) and austenitic stainless steel mark 304. Chemical composition of those steels determined with Innov-X Systems device is presented in Table 1.

Table 1 Chemical composition of the used steels

<table>
<thead>
<tr>
<th>Material</th>
<th>C</th>
<th>Mn</th>
<th>Cr</th>
<th>V</th>
<th>Ni</th>
<th>Si</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>304</td>
<td>0.08</td>
<td>1.69</td>
<td>18.38</td>
<td>0.11</td>
<td>8.0</td>
<td>0.9</td>
<td>71.29</td>
</tr>
<tr>
<td>S235 JR</td>
<td>0.15</td>
<td>1.2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

4. CORROSION BEHAVIOR

Choosing the base material for the storage tank is made after a corrosion behavior study of the two types of materials. For corrosion resistance determination of the components from non-alloyed steel and austenitic stainless steel was selected two samples of these steels which were electrochemically tested in sodium chloride medium (3% NaCl) and acid (0.5 M HCl). Corrosion behavior was determined using an electrochemical cell and a potentiostat/galvanostat AUTOLAB, PGSTAT302N model. Applied potential was ±200mV vs OCP in cathodic and anodic and the scanning speed was 1 mV/s for NaCl and 2 mV/s for HCl.

4.1. Testing in sodium chloride environment (3% NaCl)

By representation on a logarithmic scale and drawing tangents to the cathodic branch, it was determined the anodic corrosion current values ($I_{corr}$) and the corrosion potential ($E_{corr}$) (Table 2).

Table 2 Parameters for corrosion test in sodium chloride environment (3% NaCl)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Anodic slope [V/dec]</th>
<th>Cathodic slope [V/dec]</th>
<th>Polarization resistance [Ohm]</th>
<th>$E_{corr}$ [V]</th>
<th>$I_{corr}$ [A/cm²]</th>
<th>Corrosion rate [mm/year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>S235 JR</td>
<td>0.086</td>
<td>0.399</td>
<td>3.36</td>
<td>-0.608</td>
<td>4.421*10⁻⁵</td>
<td>0.51</td>
</tr>
<tr>
<td>304</td>
<td>0.169</td>
<td>0.146</td>
<td>2.35*10⁻⁵</td>
<td>-0.329</td>
<td>4.543*10⁻⁶</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Comparing the values from the table 2 it is observing that $I_{corr}$ was shifted from the value of 4.421*10⁻⁵ A/cm² for carbon steel at 4.543*10⁻⁶ A/cm² for the stainless steel. Displacement of current density as lower values indicates a improved corrosion resistance. Moreover, the corrosion rate decreases significantly from the value of 0.51 mm/year for the non-alloyed steel parts to 0.05 mm/year of stainless steel parts.

In Figure 3 are presented the polarization curves for carbon steel and austenitic stainless steel, after testing in 3% NaCl solution.
4.2. Testing in 0.5 M HCl solution

Test results after the corrosion test of non-alloyed steel S235 and 304 stainless steel in 0.5 M HCl acid are presented in Table 3.

Table 3  Test results after the corrosion test in 0.5 M HCl solution

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>S235 JR</td>
<td>0.081</td>
<td>0.154</td>
<td>8.722</td>
<td>-0.484</td>
<td>6.227*10⁻⁴</td>
<td>7.31</td>
</tr>
<tr>
<td>304</td>
<td>0.062</td>
<td>0.128</td>
<td>72.41</td>
<td>-0.339</td>
<td>4.741*10⁻⁵</td>
<td>0.55</td>
</tr>
</tbody>
</table>

It is observing that Icorr was shifted from the value of $6.227 \times 10^{-4}$ A/cm² for the non-alloyed steel at a much lower value of $4.741 \times 10^{-5}$ A/cm² for the samples of stainless steel. It is noted an increase in corrosion resistance from a corrosion rate of 7.31 mm/year for non-alloyed steel to 0.55 mm/year of stainless steel parts. Figure 4 presents the polarization curve of test samples in 0.5 M HCl solution.
Figure 5 evidence the high corrosion resistance of 304 stainless steel in comparison with the non-alloyed steel after the corrosion tests in NaCl and hydrochloric acid:

![Figure 5](image)

**Fig. 5** Corrosion rates for the tested samples

It is observing that the stainless steel parts presents a higher corrosion resistant, with an efficiency of 92% compared with the non-alloyed steel parts tested both medium sodium chloride and hydrochloric acid.

5. **WELDING TECHNOLOGY**

The storage tank was made of AISI 304 base materials, the welding being done in open space. To realize the required tank welds are necessary provisionally welds and after filling its joints. The welding parameters used, following the certification of the technology welding, are given in Table 4.

<table>
<thead>
<tr>
<th>Intensity, [A]</th>
<th>Voltage, [V]</th>
<th>Welding speed [cm/min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>80-130A</td>
<td>28-30V</td>
<td>22</td>
</tr>
</tbody>
</table>

Tab. 4 Welding parameters

After welding operation was made strict control performed during and after welding: nondestructive testing (visual inspection, Rx, and tightness control). The control highlighted the desired quality of tank joints.

6. **CONCLUSIONS**

6.1. Storage tanks are containers that require proper execution and welding technology to ensure their proper functioning in service for long periods.

6.2. There are presented the stages of storage tanks realization and welding technology using two basic materials.

6.3. The tests of corrosion shows that the stainless steel has a high corrosion resistance, with an efficiency of 92%, compared with non-alloyed steel components tested both in medium sodium chloride and hydrochloric acid.
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