CORROSION POTENTIALS OF THE ALUMINUM ALLOYS

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Aluminum alloys has many industrial applications, based on excellent corrosion properties of these alloys [1–4]. This paper aims consist first on identifying of the corrosion potential of all classes of aluminum alloys, ie all 2xxx ÷ 7xxx series, performed in accordance with ASTM G69 and PO-042, and secondly on achieving correlations between the aluminum alloys state and corrosion potential value. Samples were prepared in accordance with PO-043, with clear delineation of the areas subject to electrochemical corrosion. Electrochemical investigations were conducted on a potentiostat type ATLAS 0531. The conclusions drawn from experiments allow a hierarchy of electrochemical corrosion resistance of aluminum alloys depending on chemical composition and state condition.

Keywords: 2xxx- 7xxx series aluminum alloys, corrosion resistance, corrosion potential

1. Introduction

Aluminum is actually a very active metal, meaning that its nature is to oxidize very quickly. While a weakness for most metals, this quality is actually the key to its ability to resist corrosion. When oxygen is present (in the air, soil, or water), aluminum instantly reacts to form aluminum oxide. This aluminum oxide layer is chemically bound to the surface, and it seals the core aluminum from any further reaction. Aluminum alloys has many industrial applications, based on excellent corrosion properties of these alloys [1–9]. This paper aims consist first on identifying of the corrosion potential of all classes of aluminum alloys, ie all 2xxx ÷ 7xxx series, performed in accordance with ASTM G69 and PO-042, and secondly on achieving structural correlations between the aluminum alloys state and corrosion potential value.

2. Materials and Experimental Procedures

The alloys that were tested under corrosion are part of all commercial aluminum alloys, respectively 2xxx ÷ 7xxx series, made by SC ALRO SLATINA.

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The equipment used for structural investigations were: CUTO 20 cutting machine, SIMPLIMET 1000 mounting press machine, PHOENIX 4000 grinding machine, metallographic BX60M Olympus microscope, equipment for measuring of corrosion potential type ATLAS 0531. The sample were prepared according to PO-043 and were analyzed according to ASTM G69 and PO-042 internal procedure. Standard ASTM G69 is referred only to alloy 3003 and indicate that a sample which correspond to it should have a value of -751 +/- 20mV. The only data specified in the standard ASTM G69 regarding the corrosion potential values are shown in Table 1.

Table 1.

<table>
<thead>
<tr>
<th>The corrosion potential values for different aluminum alloys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alloy / State</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>Corrosion potential, [mV]</td>
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</tbody>
</table>

The corrosion potential values for different aluminum alloys are illustrated in table 2.

Table 2

<table>
<thead>
<tr>
<th>Chemical composition of aluminum alloys used in experimental corrosion tests</th>
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</thead>
<tbody>
<tr>
<td>Alloy / State</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>1150 H24</td>
</tr>
<tr>
<td>5052 T651</td>
</tr>
<tr>
<td>5052 H32 (MECH)</td>
</tr>
<tr>
<td>2024 O</td>
</tr>
<tr>
<td>7075 T651</td>
</tr>
</tbody>
</table>

The chemical composition of the experimental aluminum alloys is illustrated in table 2.
The samples were cut at equal sizes (150x20mm), barb was removed by polishing at machine grinding 4000 Phoenix using abrasive paper and were degreased with acetone. The attack surface was defined as is shown in Figure 1 (between 1 to 2 cm$^2$ for the exposure surface). Then, the rest of the sample was coated with an acrylic resin, measuring for each sample the surface that was exposed to attack. After being prepared, each sample was separately tested and were taken measurements at 30 minutes and respectively 60 minutes for comparison.

![Fig.1. Samples for measuring corrosion potential (left), and with delimitation of the attack zone (right)](image)

3. Results and Interpretations

Experimental results regarding the corrosion potential values after 30 minutes, respectively 60 minutes are illustrated in figures 2 and 3.

According to ASTM G69 the corrosion potential is positively influenced by the copper concentration and in a negative way by the zinc concentration. Thus, in figure 4 is given the corrosion potential variation in terms of the copper concentration, indicating the aluminum alloy grade, and in figure 5 is specified the corrosion potential value obtained after testing in terms of the zinc concentration value.
Fig. 2 - Corrosion Potential of the 2xxx+7xxx series aluminum alloys

Fig. 3 - Corrosion Potential of the experimental aluminum alloys

Fig. 4. Copper content versus corrosion potential of the experimental aluminum alloys
Corrosion potentials of the aluminum alloys

The experimental results shown that the alloys from 2xxx series (2014, 2017, 2024) had the smallest corrosion potential, $X_{\text{mean}} = -618.8\text{mV}$. In the 3003 alloy can be noticed a stability in terms of corrosion potential, the analyzed samples both of sheets and plates (whether of the milled or laminated surface) have approximately the same values, the samples being appropriate to ASTM G69. In case of alloys from 5xxx series, as in the 3003 series, the potential values are close both between the milled front and rolled face and the measuring ranges between 30 or 60 minutes. For 6xxx series alloys yielded the highest $X_{\text{mean}} = -988.8\text{mV}$. Also, in these alloys we remarked the biggest differences between the alloys with the same delivery grades and alloys with different delivery conditions (both on the rolled face and on milled one).

For the 7xxx series alloys was observed substantial differences between the alloys of the same grade but with different chemical composition and the milled and rolled face. Only for 7075 alloy are not observed noticeable differences between the milled face and rolled one. The best values for corrosion potential values were obtained in case of 2017 alloy (-644.7mV), 2014 alloy (-733.2mV) and 2024 alloy (-737.5mV), these alloys having a solid solution Cu concentration of 4.1%; 4.4%; and respectively 4.5%, and the concentration of Zn in these cases being 0.11%; 0.06%; and respectively 0.04%. The average values for corrosion potential were obtained for 7075 alloy (-780.5mV) and 7175 alloy (-782.3mV), which had a Cu concentration in solid solution of 1.3%, and the Zn concentration around 5.7%, in according with ASTM G69. The lowest corrosion potential
values for the tested alloys were obtained for 7020 alloy (-938.9mV), this having a Cu concentration of 0.03% and in case of Zn 4.8%.

4. Conclusions

Analysis of the obtained results after identifying the aluminum alloys corrosion potential allowed the detection of the corrosion potential specific values in conjunction with the alloy grade and ranking of the aluminum brands in terms of corrosion behavior. It highlighted the need for retesting of corrosion potential for the alloys that have achieved the best values (2017, 2014, 2024), the weakest values (7022, 7020), but also for those that were obtained averages (7075, 7175). It must also be taken into account that testing must be done from at least 3 different samples for each alloy. It carried out a correlation between the aluminum alloys chemical composition and the corrosion potential values.

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