COMPARISON OF STRENGTH PROPERTIES OF ALUMINIUM 5754 ALLOY AFTER EXPOSURE IN NEUTRAL AND ACETIC ACID SALT CORROSIVE ENVIRONMENTS

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Abstract

Aluminum alloy 5754 (AlMg3) has a high welding and strength properties and also a good resistance to atmospheric and marine corrosion. The alloy is used in many industries such as automotive, railway, marine building, electricity, chemistry and forging. In this work, strength properties of aluminum alloy 5754 (AlMg3) after an acid salt spray (CASS) test and neutral salt spray (NSS) test have been investigated. It can be concluded, that after 240 hours of duration of (CASS) test of Al alloy 5754 (AlMg3), the plastic elongation A_{50} showed the greatest decreasing (up to 50%), whereas performed (NSS) test during 1512 hours (9 weeks) of the same Al alloy does not show decreasing of any strength properties. The mechanical properties of tested alloy after (NSS) test were on the same as initial level. On the basis of obtained results it can be concluded, that acetic acid salt spray (CASS) test may cause significant decreasing of strength properties which can cause too early destruction of elements used in industry.

Keywords: Corrosion resistance, CASS test, NSS test, strength properties

1. INTRODUCTION

In the industry, aluminum alloys are now widely used in the manufacture of structural parts responsible for energy absorption and crashworthiness. The aim of recent researches is being to develop passive safety of vehicles through structures fabricated using materials with the highest possible strength to weight ratio. For example aluminum alloy 5754 is a medium strength alloy with excellent corrosion resistance especially to seawater. Aluminium alloy 5754 shows good cold formability, high fatigue strength and fair machinability. This makes aluminum alloy 5754 highly suited applications, shipbuilding or chemical and nuclear structures. It is also commonly used for automotive structural members and inner body panels [1].

In this work aluminum alloy 5754 (EN AW-5754, PN PA11, ISO Al Mg3) was applied to the research in form of sheet-metal with dimension 1000 × 2000 × 1 mm. The chemical composition of tested alloy included: 95.5% Al, 3.3 % Mg, 0.34 % Fe, 0.23 % Mn, 0.19 % Si, 0.11 % Zn, 0.037 % Cu, 0.029 % Cr, 0.023 % Ti, 0.01 % Ni, 0.01 % Pb. The results were obtained by use of Spectrometer WD-XRF (X-ray fluorescence with wavelength dispersion).

The aluminum alloy 5754 was studied for corrosion resistance in salt spray chamber and accelerated electrochemical tests. The aim of study was to determine strength properties of tested alloy after long time exposure in two corrosive environments. In the literature only a trickle of information on this subject can be found [2-5].

2. EXPERIMENT AND TEST RESULTS

To the determination of corrosion influence on mechanical properties of tested material the strength specimens were exposed to neutral and acidic (with the addition of $CuCl_2$) salt spray impact [6]. The test specimens were prepared according to EN-ISO 6892-1:2016 [6] as type 1, with width b_o 12.5 ± 0.05 mm, and original gauge length 50 mm, with parallel length 62 mm. An example of appearance of tested specimens after corrosion tests are shown in **Figures 1, 2**. The outside surface observed under higher magnification is presented in **Figure 3**. The exposure was performed suitably at a temperature of 35°C (NSS test) and 50°C (CASS test) and specimens were periodically drawn out from the corrosion chambers at every 24 hours during coursing of experiment in acid corrosion test (CASS) and at every week in neutral corrosion test. The corroded specimens were subjected to testing of strength properties and elongation (R_m, $R_{p0.2}$, A_{50}) according to EN ISO 6892-1: 2016 [7].

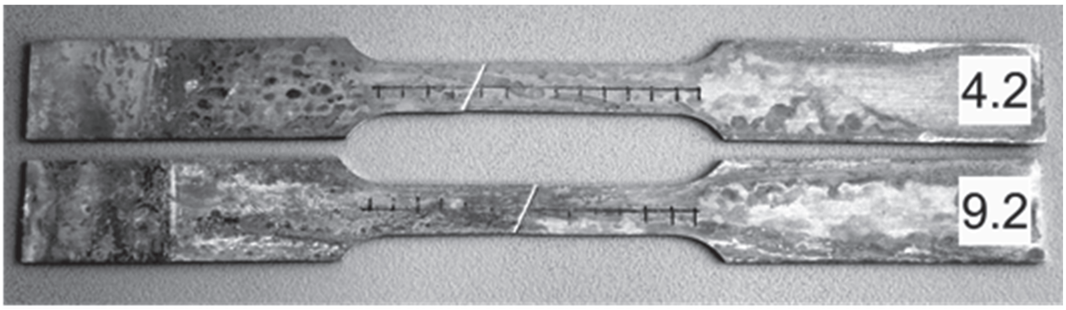

Figure 1 Tensile specimens after fracture, before tensile test specimens were exposed in environment of NSS test for 672 h (4.2) and 1512 h (9.2)

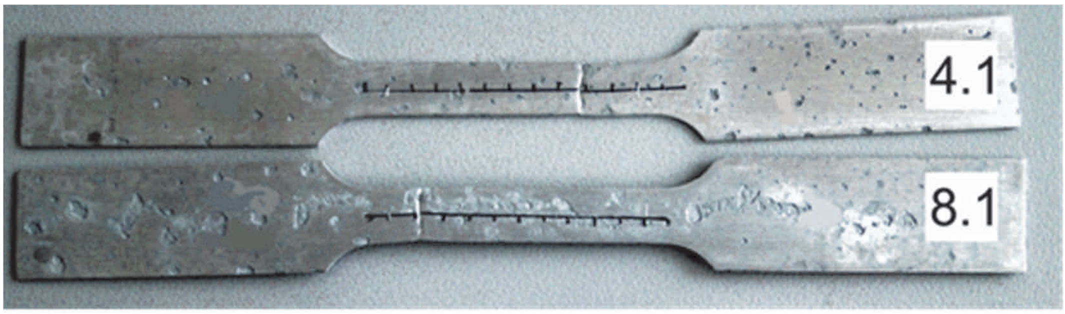

Figure 2 Tensile specimens after fracture, before tensile test specimens were exposed in environment of CASS test for 24 h (4.1) h and 192 h (8.1)

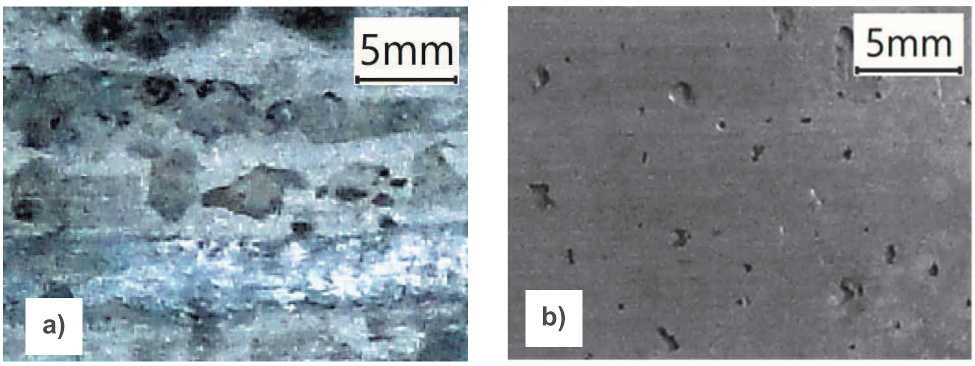

Figure 3 The appearance of the specimens surface after corrosion tests: a - in NSS test (672 h); b - in CASS test (24 h)

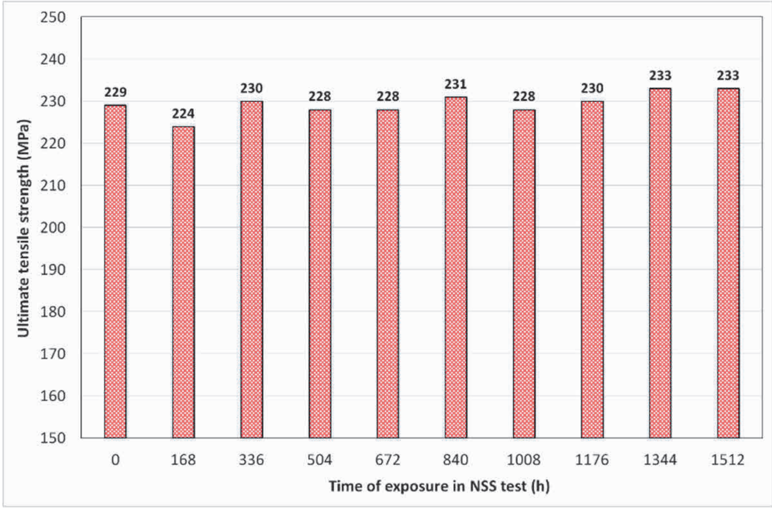

Figure 4 Ultimate tensile strength as a function of time in NSS test

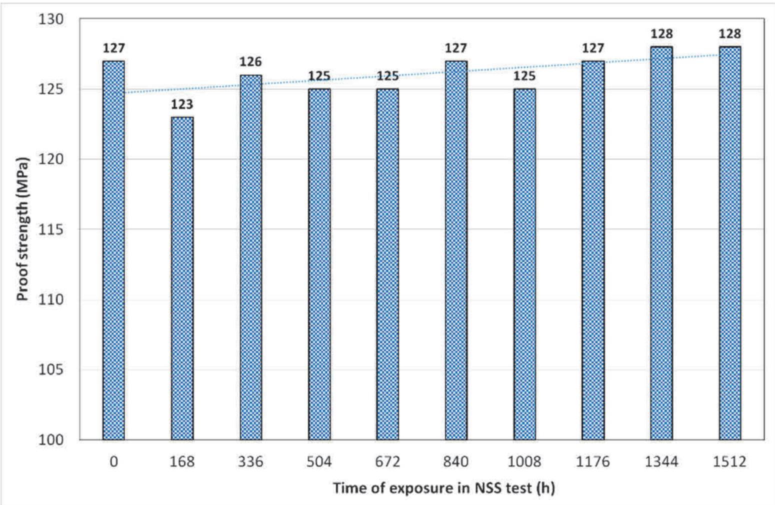

Figure 5 Proof strength as a function of time in NSS test

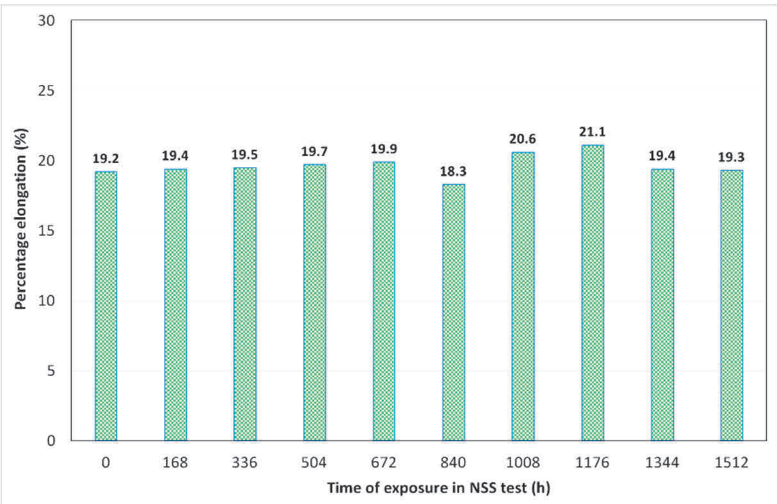

Figure 6 Percentage elongation as a function of time in NSS test

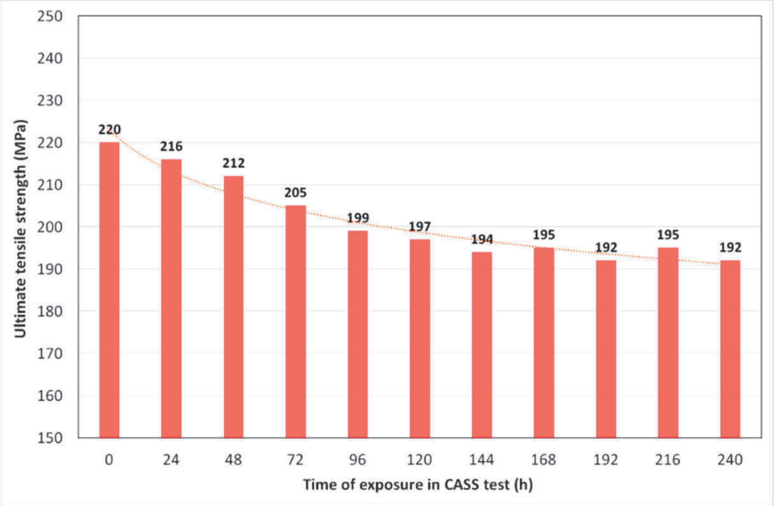

Figure 7 Ultimate tensile strength as a function of time in CASS test

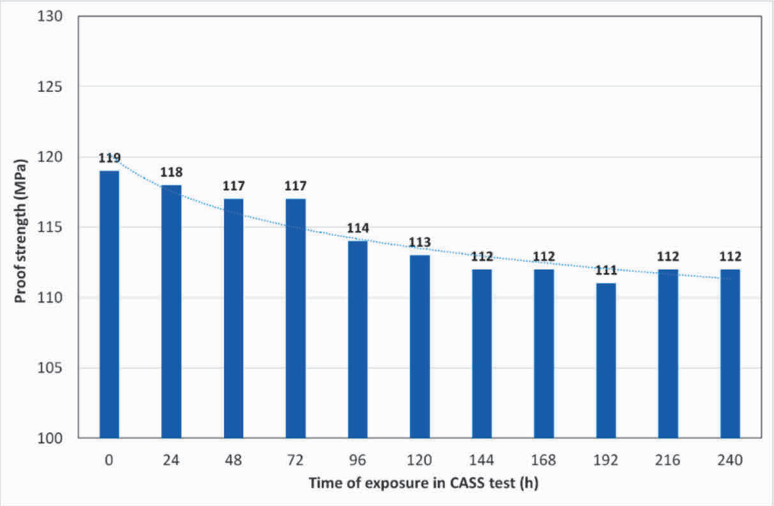

Figure 8 Proof strength in function of time in CASS test

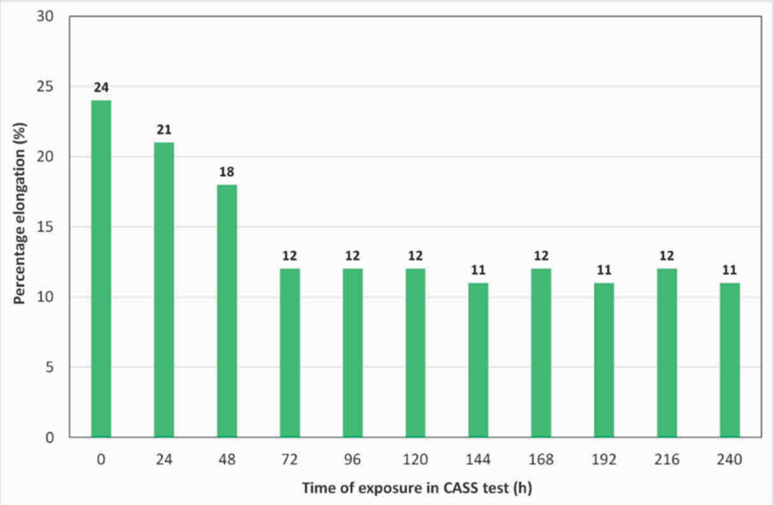

Figure 9 Percentage elongation in function of time in CASS test

3. RESULTS OF ANALYSES

The achieved results (**Figures 3-9)** allow for the explicitly evaluation of analyzed material behavior both in acidic as well as neutral salt spray environment. The surface of tested specimens with the passage of test time is undergoing the corrosion, in addition in case of the NSS test corrosion effect is observed only in the form of grains size etching, while in the case the CASS test on the surface of specimens corrosion pits appeared with different dimensions - **Figure 3**. The size of observed pits increases with time of the test. After 24 h pits are about 1 mm wide, whereas after 192 h their dimensions reach even 4-5 mm - **Figures 2, 3b**. The measured values of strength properties and elongation (R_m, $R_{p0.2}$, A_{50}) of tested specimens presented in **Figures 4-6** are the consequences of observed corrosion process. The measured values of mechanical properties during the NSS test changes in the following ranges: R_m: 224-233 MPa, $R_{p0.2}$: 128-123 MPa; A_{50}: 21.1-18.3 %. In addition in the entire examined time period (0-1512 h) there is no observed of explicit change of the properties trend. So, it could be assumed that effect of the corrosion of aluminum alloy 5754 in NSS spray environment is such slight that doesn't cause substantial changes of measured mechanical properties.

The situation in the case of CASS test is quite different. The measured values of mechanical properties change within the range: R_m: 220-192 MPa, $R_{p0.2}$: 119-112 MPa; A_{50}: 24-11 %. The observed trend consist in properties value decreasing with time passage (0-240 h). The biggest properties reduction is observed in the first period of the test, i.e. between 0 and 96 h ($\Delta_1 R_m$=21 MPa, $\Delta_1 R_{p0.2}$ = 5 MPa; $\Delta_1 A_{50}$= 12 %).The further time passage (96-240 h) doesn't result in essential properties change ($\Delta_2 R_m$=7 MPa, $\Delta_2 R_{p0.2}$ = 2 MPa; $\Delta_2 A_{50}$= 1 %). So, the inspected alloy is much less corrosion resistant in acidic salt spray environment and this effect is transferred for the significant reduction of measured mechanical properties, in addition in the studied case instead of R_m, $R_{p0.2}$ rather values of measured forces should be considered because in the course of conducted test the dynamic specimens cross section reduction is undergoing (the considered R_m, $R_{p0.2}$ values are underestimated), as a result of pits creation which influence is difficult to determine. From the other side the progressing corrosion can also reduce R_m, $R_{p0.2}$ and A_{50}, as a result of internal processes, but also this influence is difficult to determine.

4. CONCLUSIONS

- Studies shows that acid salt spray, CASS test causes faster illusory decreasing of strength properties of Al 5754 alloy compared to NSS test and indicate the need to develop a new microstructural properties of alloy for parts in salt environment to apply protective layers (coatings).
- In case of the NSS test the corrosion effect is observed only in the form of grains size etching and doesn't cause substantial changes of measured mechanical properties, while in the case the CASS test on the surface of specimens corrosion pits appeared with different dimensions.
- Corrosion pits observed on the specimens surface after acid salt spray, CASS test cause specimens cross section reduction and in this case instead of R_m, $R_{p0.2}$ (underestimated) rather corresponding forces F_m, $F_{p0.2}$ should be considered.

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