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CORROSION EFFECT ON MECHANICAL PROPERTIES OF ALUMINIUM ALLOYS 2024-T351 AND 7075-T651

UTICAJ KOROZIJE NA MEHANIČKE OSOBINE LEGURA ALUMINIJUMA 2024-T351 I 7075-T651

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Keywords
- aluminium alloy 2024-T351
- aluminium alloy 7075-T651
- corrosion
- moisture
- tension properties

Abstract

Results of static tensile testing of aluminium alloys 2024-T351 and 7075-T651 are presented with different levels of corrosion exposure in the laboratory environment. Specimens from two different rolling directions are tested (parallel and transverse rolling direction) after 7 and 30 days of corrosion exposure, respectively, using SCHENCK TREBEL Prüfmaschinen 4030 Ratingen, type RM100 testing machine. The obtained results indicate the change in the tensile properties depending on the time of corrosion exposure and moisture content.

Ključne reči
- legura aluminijuma 2024-T351
- legura aluminijuma 7075-T651
- korozija
- vlaga
- zatezne karakteristike

Izvod

Predstavljeni su rezultati statičkih zateznih ispitivanja epruveta izrađenih iz dva pravca (paralelno i poprečno na pravac valjanja) iz ploča od aluminijumskih legura za vazduhoplove 2024-T351 i 7075-T651, dobijenih za dva vremenska perioda izlaganja u vlažnoj komori (7 i 30 dana, respektivno). Ispitivanja su izvedena pomoću kidalice SCHENCK TREBEL Prüfmaschinen 4030 Ratingen, tip RM 100. Analiza rezultata uključuje promene osnovnih parametara čvrstoće u zavisnosti od vremena izloženosti dejstvu kontrolisane vlage.

INTRODUCTION

For modern aircrafts made of AA2000-7000, increasingly stringent requirements are set in terms of safety and resistance to fracture, /1-4/. Specifically, corrosion damage and failure have attracted significant attention for many decades due to the strong effect on performance, /5/. Experience has shown that failures due to corrosion are extreme, causing damage in the economy of developed countries as high as 4-5% of GDP. It is also estimated that corrosion effects on aeronautical vehicles are responsible for 80 % of aging costs, on one side, and the cause of 45 % damage on the other side, reducing significantly operational safety. Therefore, it is only natural to get as much information about corrosion in aeronautical materials as possible.

Aluminium alloys 2024 and 7075 are two most common materials used for the airplane and helicopter fuselage, as well as for the wings and other components that require high ratio of static and dynamic strength with component weight.

The aim of this research is to determine the corrosion effect on the strength of Al alloys 2024-T351 and 7075-T651. Toward this aim tensile testing is performed on AA 2024-T351 and AA7075-T651 in three different states - as produced and after 7 and 30 days of exposure to moisture, i.e. corrosive environment. Previously performed experiments, e.g. /6-10/, are taken into account as the sound base for this research.

EXPERIMENTAL PROCEDURE

Testing is performed at the Military Technical Institute, Belgrade, using testing machine SCHENCK TREBEL Prüfmaschinen 4030 Ratingen, RM100, with a maximum force of 100 kN.

Using the analogous unit with an indicator of pressure change, continuous force increase is registered, while the elongation is measured using an extensometer, Fig. 1. Results are automatically transferred into Microsoft Office Excel® database, providing also the σ-ε engineering curve.

Figure 1. Specimen with extensometer, prepared for testing.

Specimens made of AA2024-T351 and AA7075-T651 are tested in a chamber with controlled moisture to analyse corrosion effects on tensile properties. Relative air moisture in the chamber is R_W = 100%, temperature t = 28-30 °C, so that corrosion is accelerated in relatively mild environment. Testing was performed for 7 and 30 days.

Table 1. Chemical composition of Al alloys, ASTM B 209-04, /11/.

	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti
2024-T351	0.50	0.50	3.8-4.9	0.3-0.9	1.2-1.8	0.10	0.25	0.15
7075-T651	0.40	0.50	1.2-2.0	0.30	2.1-2.9	0.18-0.28	5.1-6.1	0.20

Tensile testing is performed on small sized specimens, Fig. 2, in laboratory conditions (t = 25 °C, relative air moisture R_w = 55%), in strain control, with load rate 5 mm/min. Specimens are taken with parallel and transverse direction in respect to rolling. In total, 22 specimens are tested, divided into 3 groups (0, 7, and 30 days in the chamber).

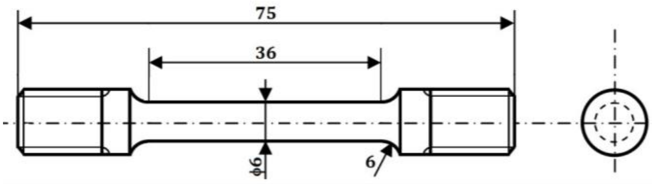

Figure 2. Small-sized tensile specimen, ASTM B 557M-02a, /12/.

RESULTS AND DISCUSSION

Stress-strain curves are shown in Figs. 3-4 for AA7075-T651 and AA2024-T351, respectively. Using the plotted values shown in Figs. 3-4, the maximum stress (tensile strength) and strain (elongation) are listed in Tables 2 and 3 for both materials and 3 exposure periods.

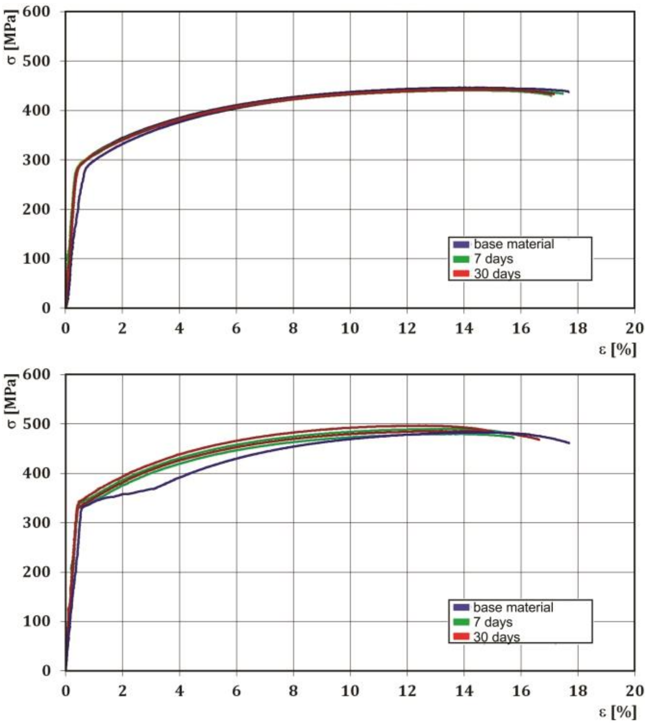

Figure 3. Stress-strain diagrams for AA7075-T651 parallel (top) and transverse (bottom) -to-rolling direction for two exposure periods.

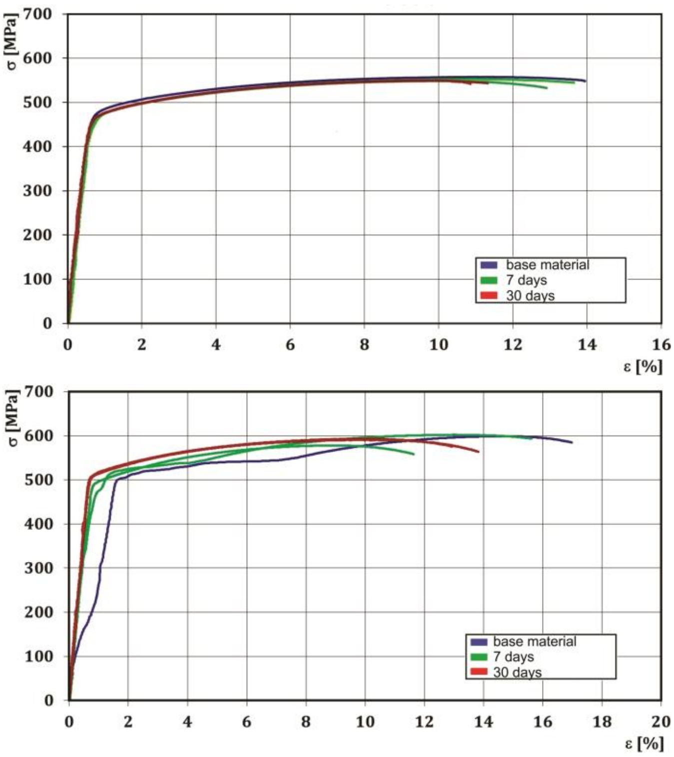

Figure 4. Stress-strain diagrams for AA2024-T351 parallel (top) and transverse (bottom) -to-rolling direction for two exposure periods.

Table 2. Tensile properties for AA7075-T651.

AA	Direction	Days spent in chamber	Tensile properties	
			σ_{max} [MPa]	ε_{max} [%]
7075-T651	transverse	0	558	13.9
		7	551	13.5
		30	550	11.1
	parallel	0	599	17.0
		7	590	13.6
		30	592	13.4

Table 3. Tensile properties for AA2024-T351.

AA	Direction	Days spent in chamber	Tensile properties	
			σ_{max} [MPa]	ε_{max} [%]
2024-T351	transverse	0	446	17.2
		7	443	16.8
		30	443	16.8
	parallel	0	483	17.7
		7	485	15.9
		30	491	15.8

Results presented in Tables 2 and 3 indicate significantly higher strength and elongation for specimens taken in the parallel direction, regardless on period of exposure. Figure 5 shows change in tensile properties depending on the corrosion exposure time. One can see that the corrosion effect on strength is negligible, whereas it has a detrimental effect on elongation, reducing it for about 20 % in the case of AA 7075-T651, and up to 10 % in the case of AA2024-T351. Figures 6-7 illustrate this effect in a different way for both alloys in the transverse and parallel direction, respectively. One can see that differences are slightly more expressed in the latter case.

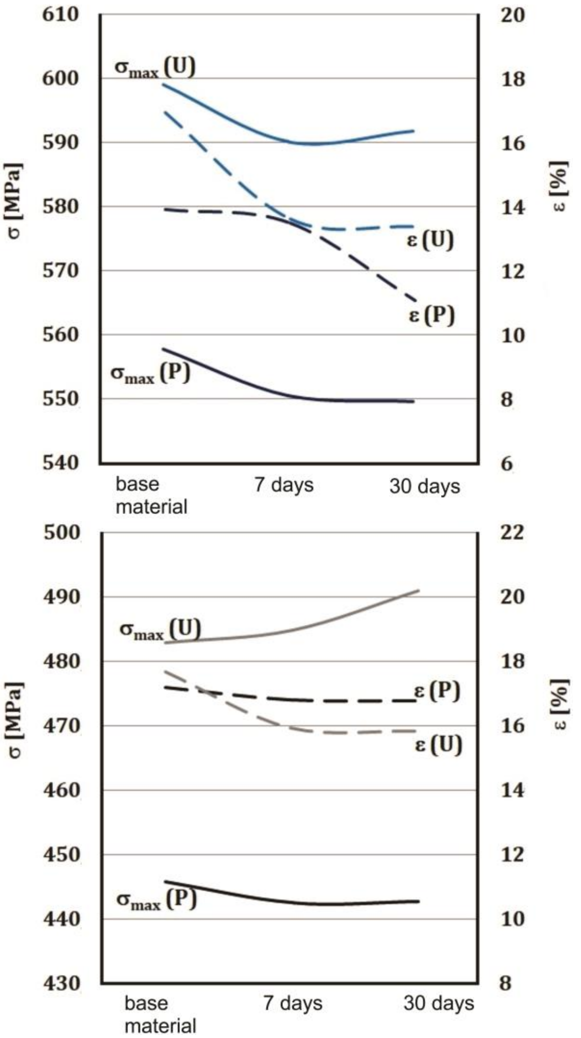

Figure 5. Strength and elongation change during exposure period for: a) AA7075-T651; and b) AA2024-T351.

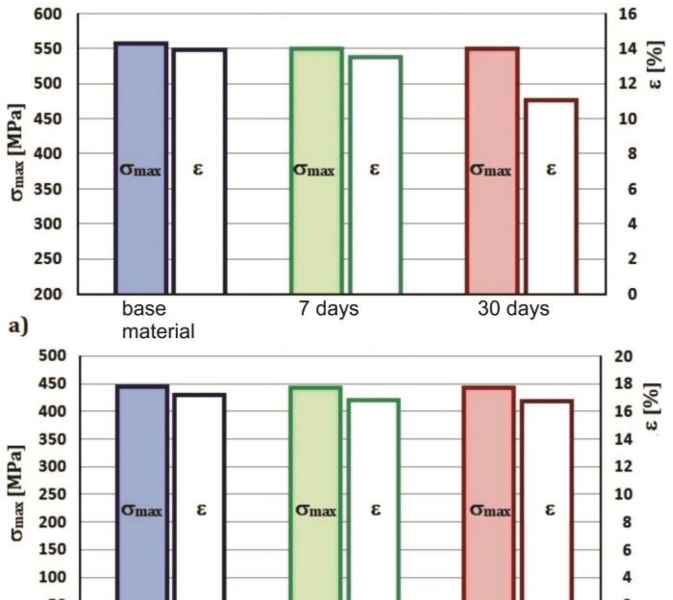

Figure 6. Comparison of strength and elongation in transverse direction, for: a) AA7075-T651; and b) AA2024-T351.

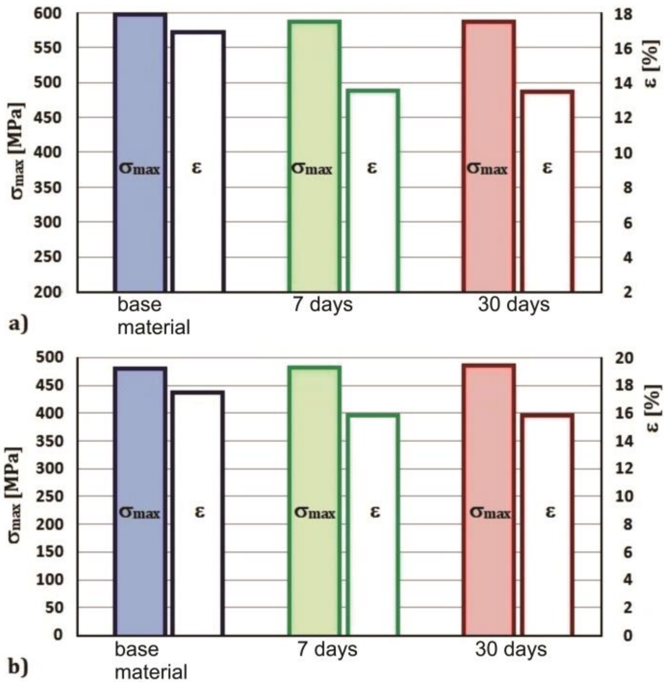

Figure 7. Comparison of strength and elongation in the parallel direction, for: a) AA7075-T651; and b) AA2024-T351.

CONCLUSIONS

Based on presented results we conclude the following:

- Corrosion effect on strength is negligible in the 30 day period, while the effect on elongation is more or less significant and noticeable already after 7 days.
- Significant differences are noticed for specimens taken in different directions, the transverse and parallel -to-rolling direction, with higher values for both strength and elongation in the parallel direction. Anyhow, a much more decrease in the elongation is recorded in the parallel direction, bringing it to the level of elongation in the transverse direction.

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Notification of Acceptance/Rejection	Dec 15, 2021
Final Paper (Camera Ready) Submission & Early Bird Registration Deadline	Aug 31, 2022
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