THE EFFECT OF ARTIFICIAL AGEING HEAT TREATMENTS ON THE CORROSION RESISTANCE OF 2198 (Al–Cu-Li) ALUMINIUM ALLOY

N.D. Alexopoulos[1], A. Proiou[1], S.K. Kourkoulis[2], Stefan Riekehr[3] and Nikolai Kashaev[3]

[1] University of the Aegean, Department of Financial and Management Engineering, 821 32 Chios, Greece

[2] National Technical University of Athens, Department of Mechanics, Laboratory of Testing and Materials, Theocaris Building, Zografou Campus, 157 73 Athens, Greece

[3] Helmholtz-Zentrum Geesthacht, Institute of Materials Research, Materials Mechanics, Geesthacht, Germany

1. Introduction

Third generation Al-Cu-Li aluminum alloys such as the AA2198 offers great capabilities in terms of weight reduction and improved mechanical properties. The lower density of the latter seems to be one of its main advantages when compared to the conventional AA2024, which is currently used in aerostructures. Though its microstructural strengthening precipitates, e.g. δ' (Al_3Li), θ' (Al_2Cu), δ (AlLi) and T_1 (Al_2CuLi) are well reported in international literature, its mechanical properies are as yet not widely considered. The respective literature is limited mainly to the investigation of the plastic and fracture behavior [1], while in [2] the anisotropic deformation of AA2198 with and without the presence of artificial notches was investigated.

In order for the Al -Cu- Li alloy to replace the conventional AA2024 in aircraft structures, it has to be proven that its mechanical behaviour, damage tolerance capabilities and corrosion resistance are at least equal or superior to its predecessor. In the present work, the authors will try to report and compare AA2198 and AA2024 mechanical behaviour for different artificial ageing conditions. The aged materials will be afterwards exposed to the same corrosion solution so as to investigate their corrosion resistance for the different artificial ageing conditions.

2. Experimental procedure

The material used was AA2198 wrought aluminum alloy that was received in sheet form of nominal thicknesses equal to 3.2 mm. The weight percentage chemical composition of the 2198 alloy is <0.08 % Si, <0.01 % Fe, 2.9-3.5 % Cu, <0.5 % Mn, 0.25-0.8 % Mg, 0.8-1.1 % Li, 0.35 % Zn, 0.04-0.18 % Zr, 0.1-0.5 % Ag. Tensile specimens were machined along the longitudinal (L) direction of the material according to the ASTM E8 specification.

Different artificial ageing conditions were performed for the total 60 tensile specimens at the $170^{o}C$ ageing temperature in an electric oven with $\pm$ $0.1^{o}C$ temperature control and for different times. Ageing times were selected to correspond to all ageing conditions, including Under-Ageing (UA), Peak-Ageing (PA) and Over-Ageing (OA). Prior to corrosive solution exposure, all surfaces of the specimens were cleaned with alcohol according to ASTM G1 specification. Tensile specimens were afterwards exposed to the laboratory exfoliation corrosion environment (hereafter called EXCO solution) according to ASTM G34 specification. A common, 2 hour exposure time was selected to corrode the tensile specimens as in [3], this exposure time gave low corrosion-induced surface pitting on AA2024 and the degradation of ductility was attributed to hydrogen embrittlement. A servo-hydraulic Instron 100 kN testing machine was used for the mechanical tests. Tensile tests were carried out according to ASTM E8 specification. An external extensometer was attached to the specimen's surface at its reduced cross-section gauge length. A data logger was used to store the data of axial force, displacement and axial strain from the attached extensometer in a digital file. In order for representative average values of the tensile properties to b obtained, at least three tensile tests have been carried out for each test series.

3. Results and conclusions

Typical engineering stress - strain curves can be seen in Figure 1a for aluminum alloy 2198 for the investigated artificial ageing times at 170 °C ageing temperature. It is evident that the different artificial ageing conditions have an essential effect on the stress - strain curves of the alloy. It is also clear from this figure that yield stress and ultimate tensile strength are increasing with increasing ageing time up to a maximum up till 48 hours, while an essential decrease in ductility is noticed. For longer ageing times (over-ageing condition), a gradual decrease in yield stress is noticed while ductility seems not to be essentially recovered at high ageing conditions. Extreme over-ageing (450 hours) resulted to decreased strength properties and increased strain hardening exponent.

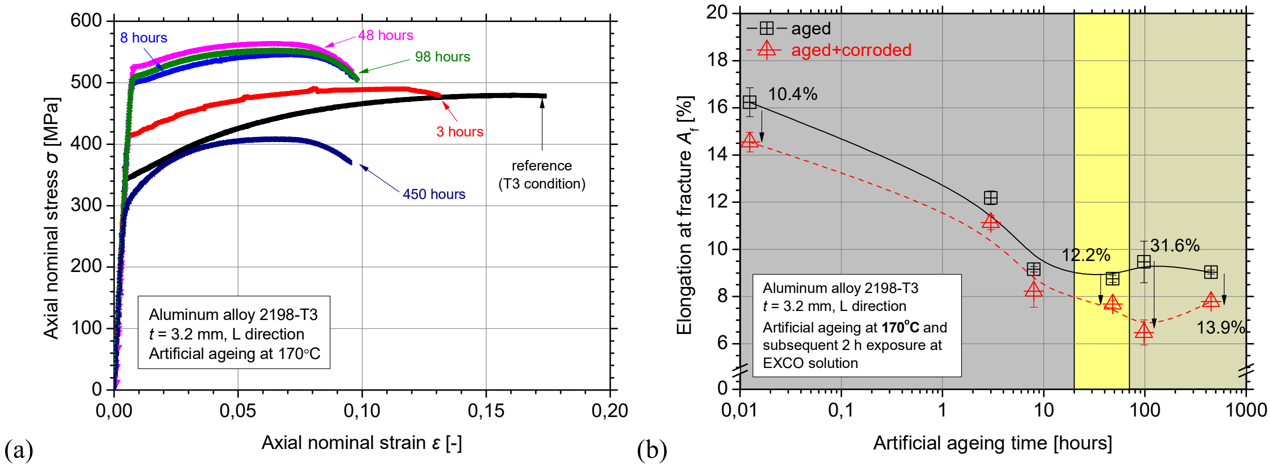

Figure 1. (a) Typical tensile flow curves of artificially aged specimens of aluminum alloy 2198 at 170°C ageing temperature and (b) evaluated tensile elongation at fracture A_f of pre corroded specimens for various ageing conditions.

Figure 1b shows the respective results for the tensile ductility (elongation at fracture A_f). After the 2 hours EXCO exposure, AA2198-T3 (without any artificial ageing) seems to maintain most of its ductility (90% of initial). On the contrary, AA2024 of same thickness lost almost 25 % of its initial tensile ductility. Of course this effect was well explained in the literature and was attributed to hydrogen embrittlement. Hydrogen is generated during the first corrosion stage and it is then diffused inside the specimen's microstructure; this produces local surface embrittlement that influences the macro-property of ductility. For higher ageing times, e.g. in the peak-ageing condition, almost the same ductility decrease is noticed; about 12 % (average) elongation at fracture decrease is evident for the peak-aged specimens, clearly showing that the fracture mechanism (embrittlement) has not essentially changed. For even higher ageing times (over-ageing condition) the corrosion- induced degradation changed again as the ductility decrease was increased and needs further investigation.

4. References

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