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TENSILE MECHANICAL BEHAVIOUR OF AERONAUTICAL 2024 AND 2198 ALUMINUM ALLOYS AFTER CORROSION EXPOSURE

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ABSTRACT

This work compares the corrosion resistance in terms of residual tensile mechanical properties of the conventional aeronautical sheet alloy 2024-T3 against the third generation aluminum-lithium alloy 2198-T351. Tensile test specimens from respective sheets were machined to evaluate the tensile mechanical behaviour of the two alloys. Other specimens were pre-corroded in accelerated corrosive environment according to the ASTM specifications. The pre-corroded specimens were tensile tested and the remaining tensile mechanical behaviour of the two different alloys was evaluated. Differences in the corrosion-induced structural integrity between the two alloys are reported and discussed.

Keywords: mechanical behaviour, corrosion exposure, tension, degradation.

INTRODUCTION

The widely used aluminum alloy is the damage-tolerant Al 2024-T3 alloy used in the skin and the wings of the aircraft. A study has been performed on repairs of the fuselages of 71 Boeing 747 aircraft with an average life of 29,500 flight hours and was briefly discussed in (Vogelesang and Vlot, 2000). These repairs were classified according to the type of damage. The distribution over the damage types was 396 repairs of fatigue cracks (57.6%), 202 repairs of corrosion damage (29.4%), and 90 repairs of impact damage (13%). This analysis provides evidence of the need to investigate corrosion damage in order to preserve the structural integrity of specific aircraft materials and structures (Alexopoulos and Papanikos, 2008).

The main driving force in aircraft structural design and aerospace material development is to reduce weight. On the other hand, the need to reduce emissions in order to contribute to the environmental sustainability has forced aviation industry to invest in developing new materials and designs with the double objective of reducing the weight of structural components of the aircraft and improving mechanical properties.

Al-Li alloys are considered those aluminium alloys containing between 0.5 and 3.5 wt.% of lithium. Li is added to Al-Cu alloys from the series 2xxx in a lower proportion than the Cu addition. The introduction of recently developed Al-Cu-Li metallic materials is easier as they can be manufactured with the existing machining, forming and assembling equipments. They offer lower density than conventional aluminium alloys and direct weight reduction of about 5%. It is projected that the improved property balance i.e. corrosion resistance, fatigue crack growth rate, strength and toughness, allows further weight reduction up to 20% through adapted design, and reduction of aircraft maintenance costs as well.

In the present work, the tensile mechanical behaviour of the conventional 2024-T3 and 2198-T351 alloy will be compared; their corrosion resistance in terms of remaining tensile mechanical behaviour after accelerated corrosion exposure will also be evaluated.

RESULTS AND CONCLUSIONS

Typical nominal tensile stress-stain curves of the two investigated alloys can be seen in Fig. 1. Alloy 2024-T3 exhibits high yield and ultimate tensile strength values and high ductility that exceeds 20% elongation to fracture (Alexopoulos, 2009). On the contrary, alloy 2198-T351 exhibits even higher ductility properties (>25%) but lower strength properties.

Their tensile mechanical behaviour was evaluated after pre-corrosion in exfoliation corrosive environment; a direct comparison between the two alloys regarding their corrosion behaviour and degradation of mechanical properties is documented and discussed.

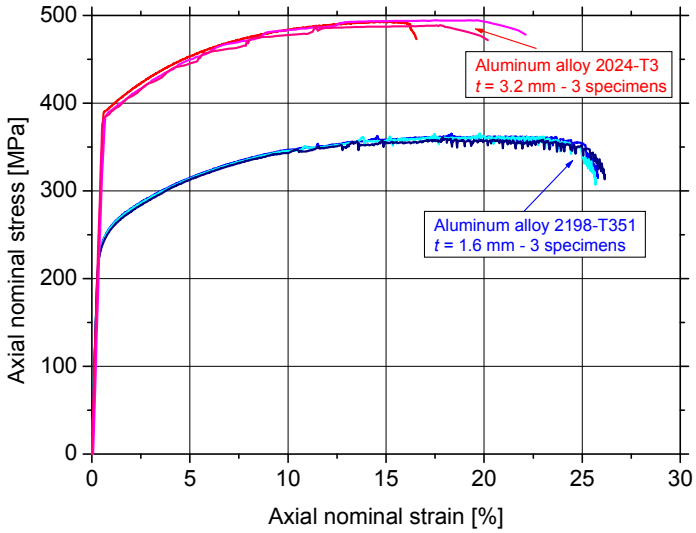

Fig. 1 - Tensile test flow curves results

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REFERENCES

[1]-Alexopoulos ND and Papanikos P. Experimental and theoretical studies of corrosion-induced mechanical properties degradation of aircraft 2024 aluminum alloy. Materials Science and Engineering A, 2008, 498, p. 248-257.

[2]-Alexopoulos ND. On the corrosion-induced mechanical degradation for different artificial aging conditions of 2024 aluminum alloy. Materials Science and Engineering A, 2009, 520, p. 40-48.

[3]-Vogelesang LB and Vlot A. Development of fibre metal laminates for advanced aerospace structures. Journal of Materials Processing Technology, 2000, 103, p. 1-5.