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TENSILE HARDENING BEHAVIOUR AND FRACTURE TOUGHNESS OF AERONAUTICAL 2198-T351 ALUMINUM ALLOY

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ABSTRACT

Third generation aluminum - lithium alloy 2198 in the T351 condition is mechanically tested in this article; tensile test results as well as fracture toughness evaluation is reported in this article. It has been shown that 2198-T351 presents higher ductility values that the conventional 2024-T3 aluminum alloy, currently employed in the aeronautical industry. However, this was not the case for the nominal tensile stress values, yield strength and ultimate tensile strength, respectively. Fracture toughness test results showed that 2198 presents higher values than 2024-T3.

Keywords: aluminum alloy, tensile test, fracture toughness, work hardening.

INTRODUCTION

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, which is responsible of the 2 % of yearly global emissions, to optimize fuel consumption by reducing aircraft weights. The agreement signed by airlines and aircraft companies in the Summit on Climatic Change held in New York in September 2009, in which they set an objective of reducing emissions by 50% below 2005 levels by 2050, will further force the 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.

Due to their high stiffness-to-weight and strength-to-weight ratios, aluminum alloys have been the dominant aircraft materials for many decades. In order to compete the decreasing tendency of Al usage in aero structures (in contrary to composites), aluminum alloy producers are making a huge effort in developing lighter and more weldable alloys. They have now focused all their attention in lithium containing aluminum alloys, not only because weight can be saved, but also because weldability of Al-Cu and Al-Zn alloys can be improved. These alloys can be welded, thus eliminating thousands of rivets resulting in a lighter and stronger integral structure (Astarita et al, 2012).

Al-Li alloys are considered those aluminium alloys containing between 0.5 and 3.5 wt.% of lithium. Li can be the main alloying element or a secondary alloying element. In the first case, Al alloys belong to the series 8xxx, as, for example, the 8090 or 8091 alloys. In the latter case, Li is added to, for example, 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 (Steglich et al, 2010). They offer lower density than conventional aluminium alloys and direct weight reduction of about 5%. The improved property balance i.e. corrosion resistance, fatigue crack growth rate, strength and toughness (Chen et al., 2011), allows further weight reduction up to 20% through adapted design, and reduction of aircraft maintenance costs.

RESULTS AND CONCLUSIONS

Tensile test results has shown that 2198-T351 presents higher ductility values that the conventional 2024-T3 aluminum alloy, currently employed in the aeronautical industry. Alloy 2198-T351 exceeds 25% elongation to fracture values, on the contrary to 2024 that hardly exceeds 20%. Nevertheless, this gain in ductility is not followed in an increase in tensile strength properties. Conventional 2024-T3 presents by almost 20% higher nominal tensile stress values, namely yield strength and ultimate tensile strength, respectively. Work hardening behaviour as well as fracture toughness characteristics are reported and discussed in the manuscript.

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