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Crack growth behavior of AA6082 and AA6061 aluminum alloys

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Abstract

Fatigue crack propagation tests have been performed in two heat-treated AlMgSi aluminum alloys under constant amplitude loading and peak overloads. All experiments were performed, in load control using M(T), specimens. Crack closure was monitored in the tests by the compliance technique using a pin microgauge. A strong material dependence effects on the fatigue crack growth were observed. The crack growth behavior of heat-treated aluminum alloys depends mainly on whether the dominant closure mechanism is plasticity-induced or roughness-induced. The enhancement of roughness-induced closure promotes higher crack growth resistance in these alloys. Roughness-induced closure dominates crack closure in 6061-T651 alloy, while in 6082-T6 aged hardened alloy plasticity-induced closure is dominant.

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Keywords: Age-hardened aluminium alloys; Crack propagation; Overloads; Crack closure

1. Introduction

The influence of mean stress on the fatigue crack growth rate has been explained with success by the crack closure using the normalized load parameter U [1]. It is generally accepted that fatigue crack growth in the Paris regime is only weakly dependent on the materials microstructure when represented against ΔK_{eff} [2]. However, when da/dN is plotted against ΔK a number of examples of microstructure-dependent fatigue crack growth were reported in the literature [3]. In all cases, accordingly with Bergner and Zouhar [3], the crack growth behavior depends mainly on whether an alloy presents plasticity-induced crack closure only, or additionally other retarding

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mechanisms such as roughness-induced closure. The present work intends to analyze the fatigue crack propagation in two heat-treated aluminum alloys, namely the 6082–T6 and 6061-T651 age-hardened alloys.

2. Experimental details

This research was conducted using AlMgSi aluminum alloys with a T6 heat treatment, namely the AA6082-T6 and AA6061-T651 alloys. These alloys differ mainly in the silicon, manganese and chromium contents. The alloys have similar monotonic and cyclic mechanical properties. Fatigue crack growth tests were undertaken, in agreement with ASTM E647 standard [4] using M(T) specimens. For 6061-T651 aluminum alloy 3, and 6 mm thickness specimens were used. The thickness of 6082-T6 aluminum alloy specimens was 3 mm. Load-displacement behavior was monitored using a pin microgauge elaborated from a high sensitive commercial axial extensometer. The opening loads, P_{op}, were obtained from these records using the correlation coefficient maximization technique [5].

3. Results and discussion

Fig. 1a) shows the comparison between the crack growth behaviors of alloys 6082-T6 and 6061-T651 under the same stress ratio R=0.05. The correspondent crack closure levels are presented in Fig. 1b).

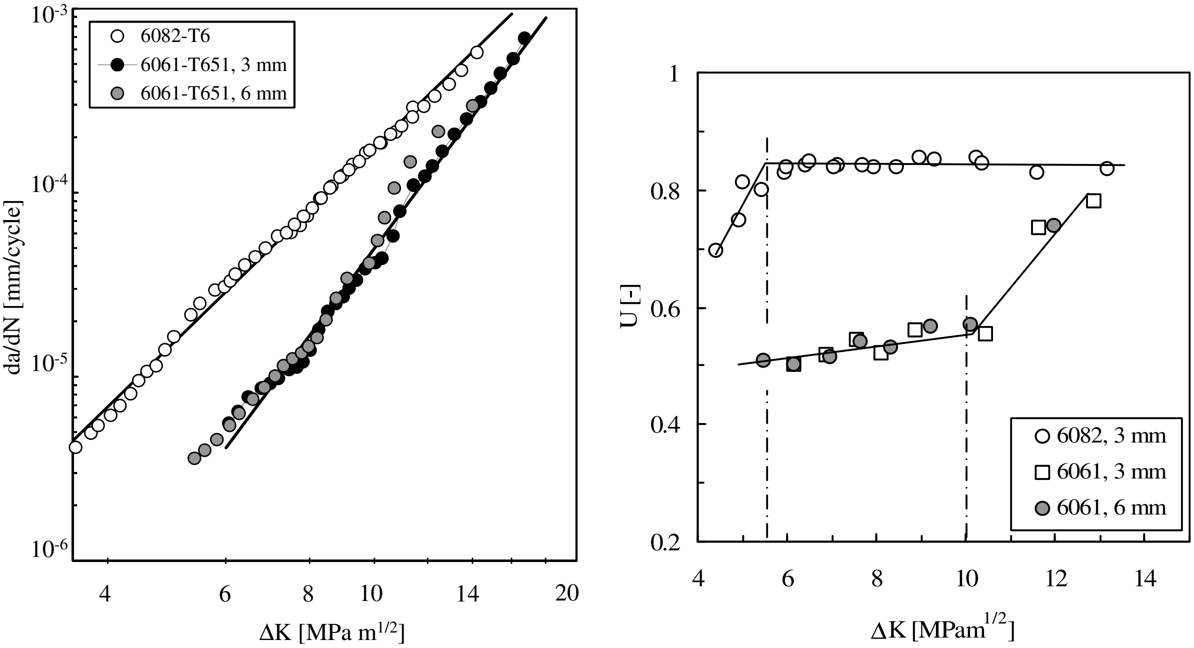

Fig. 1. Comparison between aluminium alloys 6082-T6 and 6061-T651 at R=0.05: (a) fatigue crack growth rates; (b) crack closure level.

Fig. 1a) shows that crack growth rates for alloy 6061-T651 are significantly lower than the ones obtained for alloy 6082-T6. Therefore, in spite of similar monotonic and cyclic properties, alloy 6061-T651 presents a significantly higher resistance to crack propagation. Moreover, the crack growth behavior observed for the 6082-T6 alloy is quite different of the relatively wavy appearance of the da/dN curves observed for 6061-T651 alloy. This figure also clearly shows that specimen thickness has no significant influence in the crack growth behavior of alloy 6061-T651.

Fig 1b) shows that the crack closure data are in accordance with the observed variation in the crack growth rates presented in Fig. 1a), *i.e.*, higher closure levels for lower da/dN values. Alloy 6061-T651 presents a significant higher crack closure level than alloy 6082-T6. This behavior is attributed to the abrupt change of the propagation