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Marker load-aided bidirectional fatigue crack growth rate measurement via a semi-elliptical surface crack

Yinghao Dong[a], Xiaofan He[a,*], Yuhai Li[b]

[a]*School of Aeronautic Science and Engineering, Beihang University, Beijing 100191, China*
[b]*Aviation Industry Corporation of China, Beijing 100022, China*

Abstract

It is always impractical to measure the fatigue crack growth rate in the thickness direction of a plate using a standard specimen because of the limited plate thickness. To address this issue, we proposed a method for crack growth rate measurements utilizing a semi-elliptical surface crack, the size of which is determined via marker bands. This method allows the crack growth rates both in the surface direction and the thickness direction to be measured in a single test. The core of the method involves the load spectrum development and the crack growth data analyses. In the load spectrum development, the number of marker load cycles in a load block is estimated through a crack growth equation including the crack closure effect, while the interval of marker load blocks is determined using the crack length measured in a pilot test. The estimated parameters can be amended using the crack growth data acquired by fractographic analyses, should unclear marker bands or unreasonable band spacing occur. In the crack growth data analyses, a closed stress intensity factor solution for a surface-cracked plate with clamped ends was developed, facilitating stress intensity factor calculations. Finally, we demonstrated an application of the proposed method, i.e. fatigue crack growth rate measurements for Ti-6Al-4V plates. Fine and legible marker bands were observed by fractography, and the resulting $\mathrm{d}a/\mathrm{d}N - \Delta K$ curve was consistent with the curves obtained by using standard specimens, justifying the proposed method.

Keywords: fatigue crack growth rate, surface crack, marker load, quantitative fractography, Ti-6Al-4V

*Corresponding author. Tel.: +86 01082315738.
Email address: xfhe@buaa.edu.cn (Xiaofan He)