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Experimental studies into short crack growth

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ABSTRACT

This paper examines short crack growth in two quite different materials, viz: 7050-T7451 aluminium alloy and a head hardened rail steel. The experimental data reveals that the so called short crack effect associated with 7050-T7451 aluminium alloy arises as a consequence of attempting to relate da/dN to the range of the stress intensity factor (ΔK). We also find that, in both cases, cracking crack growth conforms to the Generalised Frost–Dugdale model.

1. Introduction

This paper arose from the study of short crack growth in two very different materials. The first case involved the growth of short cracks in 7050-T7451 aluminium alloy. This study arose from an investigation into the crack length versus cycles data presented in the compendium of F/A-18 fatigue crack growth data by Molent et al. [1]. This compendium examined more than 350 different cracks mainly in 7050-T7451, but also in other 7000 series aluminium alloys, Mil Annealed Ti–6Al–4V titanium, and AF1410 steel that arose in a variety of full scale fatigue tests and associated coupon tests. Cracking in Mil Annealed Ti–6Al–4V specimens tested under a representative F/A-18 flight spectrum was subsequently studied in [2]. On examining the crack length versus cycles data presented in [1,2] it was found that the majority of the fatigue life was generally consumed in the short crack regime, i.e. in growing to a size of approximately 1 mm. As such understanding the growth of short cracks was particularly important. It was also found [1] that in almost all cases there was a near linear relationship between the log of the crack length/depth and the number of load blocks/flight hours and that this relationship held from a starting length of less than 100 μm to lengths in excess of 5 mm's.

The second problem area studied was associated with the formation and the subsequent growth of small sub mm rail squats [3]. Squats were first observed in Australia over 19 years ago and in February 1999 the problem was identified as being among the top 6 high priority items [3] in railway engineering. As such characterising the growth of sub mm cracks in head hardened rail steel is vital if we are to fully understanding this problem.

As part of the F/A-18 program undertaken by the Australian Defence Science and Technology Organisation [3,4] it was found that, for initial defects that had a size of approximately 3 μm, the crack growth programs FASTRAN[1] [6] and AFGROW (footnote 1) [7] were unable to model this (near) linear relationship between the log of the crack depth and the number of load blocks/flight hours. The need to develop a fracture mechanics based methodology that could accurately predict the growth of

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[1] Unmodified and uncalibrated.

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