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Effects of compressive residual stress on short fatigue crack growth in a nickel-based superalloy

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Abstract

The effects of compressive residual stress on short fatigue crack growth in Inconel 718 have been investigated. Using two different indentation procedures, controlled plane-strain compressive residual stress fields were applied to short through-thickness cracks, which had been generated by machining away wakes of long cracks that had been grown down to threshold levels at a stress ratio of 0.1. Short fatigue crack growth tests were conducted at stress ratios of 0.1 and 0.7. At a stress ratio of 0.1, the residual stress-free testpieces demonstrated typical short fatigue crack growth behaviour, indicated by a reduction of threshold value and increases in fatigue crack growth rates compared to those of long fatigue cracks. A significant decrease in short crack growth rates was observed within the compressive residual stress region of indented testpieces, together with an increase of threshold values. At a high stress ratio of 0.7, any similar decrease in rate is barely observable. This indicates that the effects of compressive residual stress on short fatigue crack growth are monotonic in sign and could perhaps be simulated by a crack closure approach similar to that applied for long fatigue cracks. However the superposition principle which incorporates the compressive residual stress as a negative stress intensity factor, despite many successful applications to long fatigue cracks, is found to be inappropriate here. Hence one should be cautious when extending such a methodology to short fatigue cracks as it may result in optimistic life estimations.

Key words Residual stress, fatigue threshold, short fatigue crack growth, superposition principle

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