Growth and interaction of high temperature fatigue cracks nucleated from multiple holes under small or large scale yielding

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INTRODUCTION

The purpose of this work in alloy Haynes 188 is to investigate situations where multiple cracking can occur under high temperature and when loading can vary from small scale to large scale yielding. This situation can occur in combustion chamber of aerospace engines that consisted in annular structure with thin plates perforated by numerous cooling holes and dilution holes. Severe thermal-mechanical loading conditions can induce the nucleation and growth of multiple cracks under aggressive environment.

EXPERIMENTAL RESULTS

A special specimen was designed to study interactions of stress and strain fields between holes and to determine the influence of these interactions on fatigue crack growth. Isothermal fatigue crack growth tests were conducted at 900°C. Different strain levels were applied, from small scale yielding to large scale yielding conditions. Results showed that the crack propagation rate increased by increasing the strain range level. Moreover, crack paths were different depending on the strain range level. For low strain ranges, crack paths were straight and perpendicular to the loading direction. For high strain ranges, comparing digital image correlation results with crack paths observations showed that cracks bifurcated along the direction of maximum local strain level. Cracks bifurcated at the end of the test because of the coalescence of cracks emanating from adjacent holes. Differences were also noticed between fracture surfaces for low strain ranges and high strain ranges.

CRACK PROPAGATION MODELLING

For low strain levels, linear fracture mechanics could be applied in order to describe crack propagation under small scale yielding. For high strain levels, linear fracture mechanics assumptions are not valid. The crack propagation model has to take into account local strain gradients. Finite element computations were made in order to obtain the local strain and stress fields. Strain gradients from finite element calculations were compared to experimental strain field measurements by digital image correlation. Strain and stress fields from finite element calculations were used to identify a crack propagation model based on a partition between elastic and plastic contributions.

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