The effect of surface damage and residual stresses on the fatigue life of nickel superalloys at high temperature

R.M.N. Fleury, E. Salvati, D. Nowell, A.M. Korsunsky, F. Silva, Y.H. Tai

PII: S0142-1123(18)30579-6
DOI: https://doi.org/10.1016/j.ijfatigue.2018.09.024
Reference: JIJF 4859

To appear in: *International Journal of Fatigue*

Received Date: 6 June 2018
Accepted Date: 24 September 2018

Please cite this article as: Fleury, R.M.N., Salvati, E., Nowell, D., Korsunsky, A.M., Silva, F., Tai, Y.H., The effect of surface damage and residual stresses on the fatigue life of nickel superalloys at high temperature, *International Journal of Fatigue* (2018), doi: https://doi.org/10.1016/j.ijfatigue.2018.09.024

The effect of surface damage and residual stresses on the fatigue life of nickel superalloys at high temperature

R.M.N. Fleury[a,*], E. Salvati[b], D. Nowell[b,c], A.M. Korsunsky[b], F. Silva[d], Y.H. Tai[d]

[a]*Institute of Mechanics and Numerical Mechanics, Leibniz University Hannover, 30167 Hannover, Germany*
[b]*Department of Engineering Science, University of Oxford, Parks Road, OX1 3PJ, Oxford, UK*
[c]*Department of Mechanical Engineering, Imperial College London, SW7 2AZ, London, UK*
[d]*Rolls-Royce plc, P.O. Box 31, DE24 8BJ, Derby, UK*

Abstract

A methodology for evaluating the effect of surface damage in the fatigue life of nickel superalloys is presented in this paper. Dents generated due to low velocity impacts of hard objects were simulated using a finite element (FE) model. The residual stress distribution underneath the dent root obtained numerically was compared with the measurements on experimentally simulated damaged specimens using ring-core milling at the micron scale through a combined Focused-Ion Beam and Digital Image Correlation technique (FIB-DIC). The numerical and experimental results for the residual stress show good agreement in terms of residual stress trends and magnitudes. The residual stress distribution obtained via the FE model was subsequently used in a fatigue short crack growth model for an estimation of the fatigue life of dented specimens. The fatigue life predictions were then compared with experimental fatigue results for the nickel superalloy at high temperatures. The comparison shows a significant improvement in the prediction of fatigue life of parts with superficial damage due to careful consideration of the residual stresses around the damage.

Keywords: surface damage; residual stress; fatigue; FIB-DIC; nickel superalloys

1. Introduction

Handling damage on the surface of components may occur during manufacturing, assembly and maintenance of aero-engines. Such damage is typically produced by low velocity impacts of

*Corresponding author.
Email address: rodolfo.fleury@eng.ox.ac.uk (R.M.N. Fleury)