Author's Accepted Manuscript

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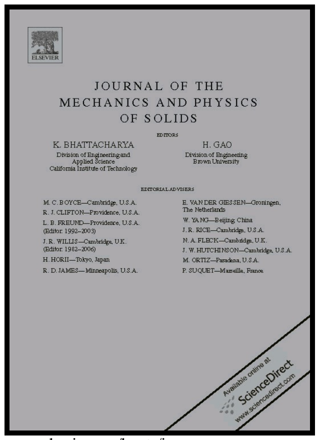

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PII: S0022-5096(16)30223-X
DOI: http://dx.doi.org/10.1016/j.jmps.2016.08.008
Reference: MPS2971

To appear in: *Journal of the Mechanics and Physics of Solids*

Received date: 5 April 2016
Revised date: 21 June 2016
Accepted date: 12 August 2016

Cite this article as: Zebang Zheng, Daniel S. Balint and Fionn P.E. Dunne, Dwel fatigue in two Ti alloys: an integrated crystal plasticity and discrete dislocatio study, *Journal of the Mechanics and Physics of Solids* http://dx.doi.org/10.1016/j.jmps.2016.08.008

Dwell fatigue in two Ti alloys: an integrated crystal plasticity and discrete dislocation study

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Abstract

It is a well known and important problem in the aircraft engine industry that alloy Ti-6242 shows a significant reduction in fatigue life, termed dwell debit, if a stress dwell is included in the fatigue cycle, whereas Ti-6246 does not; the mechanistic explanation for the differing dwell debit of these alloys has remained elusive for decades. In this work, crystal plasticity modelling has been utilised to extract the thermal activation energies for pinned dislocation escape for both Ti alloys based on independent experimental data. This then allows the markedly different cold creep responses of the two alloys to be captured accurately and demonstrates why the observed near-identical rate sensitivity under non-dwell loading is entirely consistent with the dwell behaviour. The activation energies determined are then utilised within a recently developed thermally-activated discrete dislocation plasticity model to predict the strain rate sensitivities of the two alloys associated with nano-indentation into basal and prism planes. It is shown that Ti-6242 experiences a strong crystallographic orientation-dependent rate sensitivity while Ti-6246 does not which is shown to agree with recently published independent measurements; the dependence of rate sensitivity on indentation slip plane is also well captured. The thermally-activated discrete dislocation plasticity model shows that the incorporation of a stress dwell in fatigue loading leads to remarkable stress redistribution from soft to hard grains in the classical cold dwell fatigue rogue grain combination in alloy Ti-6242, but that no such load shedding occurs in alloy Ti-6246. The key property controlling the behaviour is the time constant of the thermal activation process relative to that of the loading. This work provides the first mechanistic basis to explain why alloy Ti-6242 shows a dwell debit but Ti-6246 does not.

Keywords: Discrete Dislocation Plasticity; Dwell Fatigue; Load Shedding; HCP crystals; Nano-indentation

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