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On cold dwell facet fatigue in aero-engine components

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Abstract

This paper investigates the mechanisms of facet nucleation through combining aero-engine manufacturer disc component test data with microstructure-sensitive crystal plasticity finite element (CPFE) models. Full-scale component testing has been carried out in a manner representative of in-service conditions. Elastic FE analyses of discs under these conditions and fully accounting for thermal and residual processing strains have also been carried out. Disc facet nucleation sites have been identified and the local stress states evaluated in order to establish crystal plasticity oligocrystal sub-models. The oligocrystal RVE models provide knowledge of hard-soft grain stresses under dwell loading, and the consequent load shedding in order to provide stresses required for the facet nucleation.

The disc component facet observations together with the crystal plasticity sub-model oligocrystal approach provide persuasive evidence that a hard-soft grain combination is required for facet formation, that the remote stress state influences the resolved shear stress on the soft grain initiating slip (with tensile uniaxial stress state more damaging than a tension-tension biaxial stress state), and that the load shedding which results is essential in pushing up the hard-grain basal stress to nucleate facets.

Keywords: cold dwell fatigue; crystal plasticity; titanium alloys; aero-engine discs

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