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Multiaxial Fatigue Analysis of a High Performance Nickel-Based Superalloy

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Abstract : Over the past four decades, the fatigue behavior of nickel-based alloys has been widely studied. However, in recent years, significant advances in the fabrication process leading to grain size reduction have been made in order to improve fatigue properties of aircraft turbine discs. Indeed, a change in particle size affects the initiation mode of fatigue cracks as well as the fatigue life of the material. The present study aims to investigate the fatigue behavior of a newly developed nickel-based superalloy under biaxial-planar loading. Low Cycle Fatigue (LCF) tests are performed at different stress ratios so as to study the influence of the multiaxial stress state on the fatigue life of the material. Full-field displacement and strain measurements as well as crack initiation detection are obtained using Digital Image Correlation (DIC) techniques. The aim of this presentation is first to provide an in-depth description of both the experimental set-up and protocol: the multiaxial testing machine, the specific design of the cruciform specimen and performances of the DIC code are introduced. Second, results for sixteen specimens related to different load ratios are presented. Crack detection, strain amplitude and number of cycles to crack initiation vs. triaxial stress ratio for each loading case are given. Third, from fractographic investigations by scanning electron microscopy it is found that the mechanism of fatigue crack initiation does not depend on the triaxial stress ratio and that most fatigue cracks initiate from subsurface carbides.

Keywords : cruciform specimen, multiaxial fatigue, nickel-based superalloy
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