The AAE Summer 2019 Special Seminar Series

Presents

"Bayesian Analysis of In-Situ High-Resolution X-Ray Diffraction Synchrotron Experiments of Ti-6Al-4V Specimens Undergoing Tensile Loading"

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Wednesday, June 26, 2019
ARMS 3326
11:00 am

Abstract

The safety, airworthiness, availability and economy of the aerospace industry are underpinned by the reliability of materials, and in particular the materials used in aero-engine critical rotating components. Linking the accumulation of microstructural damage to the lifing of aero-engines components would help to better predict the time that a component spends in this crack initiation stage; i.e. before a detectable crack exists. That is, the microstructural damage to metals, which are widely used in the aerospace industry is captured in the position, shape and broadening of the X-ray diffraction line profiles. This is very important as engine lifing is based around reliable and early detection of cracks. Understanding the microstructural damage leading to crack initiation would optimise component life and result in considerable economic savings from both the original equipment manufacturers and user points of view.

We present the results and analysis of in-situ high-resolution X-ray diffraction (XRD) experiments of Ti-6Al-4V specimens that experienced tensile loading using medium energy synchrotron X-rays (≤21 keV) carried out at the Australian Synchrotron. Using Bayesian XRD analysis methods, the density, spatial arrangement of dislocations, and crystallite/domain size and distribution information for alpha- and beta-phases of the Ti-6Al-4V specimen were extracted from the XRD line-profiles, as a function of applied load. The XRD analysis was then compared and validated with transmission electron microscopy (TEM) analysis of the specimen before and after the loading. Comparison of the TEM and XRD analysis reveals broad agreement in terms of the microstructural damage of specimen.

Building on this analysis, we outline how future experiments will attempt to record the temporal evolution of microstructural damage and, the relative importance and/or influence of physical variables that give rise to crack initiation.

Bio

Nicholas obtained his Ph.D is 2000 from the University of Technology Sydney. He joined Aerospace Division at Defence Science and Technology (DST) Group, of the Australian Department of Defence in 2011, after a period as a post-doctoral researcher and scientist in the university and commercial sectors. As a senior defence scientist, Nicholas has undertaking research in probabilistic risk and reliability, Bayesian and maximum entropy methods, and materials science in the Engine and Fuels Integrity group.

In 2018, Nicholas was awarded a prestigious three year DST Chief Defence Scientist Research Fellowship. The goal of the Fellowship is to develop a stochastic model for damage accumulation leading to crack initiation, and the use of this model in the lifing of aero-propulsion components and assessing overall fleet risk.

*In collaboration with Peter A. Lynch, Sitarama R. Kada, Pavel Cizek, Justin A. Kimpton, Sonya Slater, and Ross Antoniou.