Graduate Student Research Seminar

Spring 2024

Titanium in Aggressive Environments: Investigating Creep and Dwell Fatigue Using In-situ Measurements of Microstructural Deformation Mechanisms

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Monday, February 5th

3:00 pm (EST) – 132 Fluor Daniel Building

Abstract

Aggressive environments are common across advanced applications with many of these applications benefitting from the use of titanium alloys to maximize specific strength of components that are exposed to heat and large forces, such as turbines, airframes, and skins in aeronautics and astronautics. These components are subject to creep: high temperatures and constant loads for long periods during operation, and they experience dwell fatigue as they also have periods of rest in-between operation. Creep induces many effects including inelastic strain accumulation, phase transformations, void formation, and element segregation. These effects fundamentally alter a component and can result in premature fracture and rupture. Dwell fatigue further exacerbates these issues and accelerates fracture, particularly in titanium alloys. While these effects are known and studied, it is difficult to investigate them in-situ due to dependence on underlying microstructure and scale of the resulting deformations. The proposed research uses a novel experimental setup to investigate microstructural deformation mechanisms in creep and dwell fatigue of titanium alloys. Specific mechanisms include intragranular slip, dislocation climb, and grain boundary sliding with many others possible. The interactions of these mechanisms with microstructural features, such as grain orientation, grain boundary misorientation, phase composition, grain shape, and grain size are the focus of this experimentation with their implications on macroscale creep deformation, creep rupture resistance, and dwell fatigue dwell debit. Further, there is a knowledge gap in the interactions between pre-strain deformation artifacts and creep in titanium which the proposed research will work to fill. Creep can be viewed as a push-and-pull relationship between deformation and damage from applied load with continuous annealing to allow diffusion to remove the generated defects, so an initial pre-strain to disturb this balance will have an impact on creep resistance. Pre-strained components are common as forgings and other deformation formed parts are ubiquitous, so it is of interest to better understand the impact and interactions between pre-strain induced defects and creep mechanisms. These experiments will result in an improved understanding of creep and dwell fatigue in titanium alloys that will facilitate future material development for advanced applications.

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