Experimental analysis and modeling of the effects of high temperature incursions on the mechanical behavior of a single crystal superalloy for turbine blades

ABSTRACT
Today, many components operate at high temperature and have to keep extremely good mechanical properties with time. It is in this context that nickel-based superalloys have been developed to fulfill the mechanical requirements needed for high pressure (HP) turbine blades in turboshfts due to the high temperatures (about 1920°F/1050°C) and stresses (about 120 MPa) applied. However, a new problem has appeared with the emergence of extreme operating conditions for the turbine blades of twin engine helicopters known by the acronym O.E.I. (One Engine Inoperative). These conditions are met in emergency service when one of the two engines stops. Additional power must be supplied by the engine still running leading to both a rapid increase in temperature at the turbine inlet (temperature rise from 1920°F/1050°C to 2190°F/1200°C in 5 seconds at the blades) and an increase in rotation speed of the blades. These O.E.I. regimes can be introduced at various times during certification tests (early, mid-life, end life) and repeated.

I will then talk about the non-isothermal tests performed to determine the influence of a short overheating at 1200°C on the subsequent mechanical behavior at 1050°C. During these tests, microstructural evolutions play a major role in the mechanical behavior of materials. Thus, these evolutions have been qualitatively and quantitatively quantified to predict correctly the damage and the mechanical behavior changes observed during complex thermomechanical loadings. A microstructure-sensitive model was then developed in which tailored internal variables describing major microstructural evolutions were introduced in a crystal plasticity framework to account for thermomechanical history.

BIO
Jean-Briac le Graverend received both his Diploma and Ph.D. in Aerospace Engineering in 2009 and 2013 from ISAE-ENSMA, one of the leading aerospace engineering schools in France. During his Ph.D. he was based at ONERA-The French Aerospace Laboratory. He received a fellowship from the French Ministry of Defense to work on the thermomechanical behavior of single crystal superalloys at extreme temperatures. During this research, he worked under the French program “P.R.C. Structures Chaudes” involving companies such as Snecma-SAFRAN (multinational aircraft and rocket engine manufacturer) and Turbomeca-SAFRAN (worldwide leader of turboshaf engines for helicopters) as well as French laboratories such as ONERA and several CNRS laboratories ( Mines Paris Tech, Institut P’-ENSMA, LMT-ENS Cachan and LMS-Polytechnique). He is currently at the California Institute of Technology as a Post-Doctoral Scholar in the Graduate Aerospace Laboratories. His current research on the viscoelastic characterization of electromechanical composites is funded by United Technologies Research Center. His research interests are in material degradation in severe environments (e.g. turboshaf engines); damage and failure of aerospace materials; and piezoelectric materials and structural instabilities

Refreshments will be served at 3:45 p.m.