Elevated Temperature Materials for Power Generation and Propulsion

The energy industry is designing higher-efficiency land-based turbines for natural gas-fired power generation systems. The high inlet temperatures in these systems demand further development and evaluation of high temperature structural materials for these aggressive environments. For example, Ni-base superalloys are used to fabricate blades, vanes, and rotors in these hot sections. Advanced physics-based models for prediction of thermomechanical fatigue life of the next generation’s Ni-base superalloys are being developed to enhance life assessment and management tools. Experiments are conducted in the Mechanical Properties Research Laboratory (MPRL) to develop and validate models that capture fatigue, creep, and environmental effects on crack formation and growth. Recent advances include capturing the effect of crystallographic orientation, which is significant for modeling cyclic deformation in directionally solidified and single crystal turbine blades.

Load-Bearing Surfaces in Advanced Propulsion Systems

Advances in propulsion systems for aircraft are often limited by the mechanical performance of the surfaces of the high-load bearing components, such as roller-bearing raceways and the dovetail connection between the blade and disk. Increased power and efficiency demand that improvements be made in the microstructure near these surfaces. Experiments are conducted in the MPRL to simulate fretting contacts, as shown at right (group of R.W. Neu). The results are used to develop and validate models that capture the effect of the key microstructure features, such as crystallographic orientation of the grains in the alloy, the effect of different volume fraction and distributions of phases, and defects like oxide inclusions.

As shown below, experiments within the MPRL are combined with multiscale modeling that incorporates the actual material microstructure to predict the relation between microstructure variability and property variability (e.g. fatigue strength or lifetime) in advanced alloys for aerospace propulsion applications. Explicit modeling of individual grains in the microstructure yields more realistic response for predicting structural performance.

http://mprl.me.gatech.edu/