Predicting Long-Term Properties of Nuclear Reactor Structural Materials using Physically-based Models

Abstract: As energy generation and manufacturing processes seek higher efficiencies process temperatures continue to increase. These higher temperatures put strong demands on the structural materials used to build plant vessels, piping, heat exchangers, and other components. Particularly for advanced nuclear reactors, economics dictate plant components with long design lives, extending beyond the available creep rupture test data. This means current plant designs are based on empirical extrapolation rules. Multiscale modeling provides a tool for accurately predicting material properties beyond the domain of existing experimental test data, leading to safer and more efficient plant designs. I discuss a multiscale model for the creep-rupture properties of a common high temperature structural steel and comment on the obstacles facing researchers trying to develop true ab initio multiscale models that can be used to design new metal alloys with better long-term, high temperature performance.

Biography: Mark Messner focuses on the mechanics of high temperature structural materials and high temperature material design. His work at Argonne National Laboratory includes multiscale modeling of metal alloys for long-term predictions of material failure, developing engineering material modeling frameworks, and investigating new high temperature design methods and design optimization techniques. He has published many journal articles, conference papers, and DOE technical reports on high temperature materials and design. He is the chair of the ASME BPV III Special Working Group on Inelastic Analysis and a member of most of the Section III, Division 5 Code committees. Prior to joining ANL he was a postdoctoral researcher at Lawrence Livermore National Laboratory where he worked on multiscale modeling of metals at high strain rates and temperatures and the design and optimization of additively-manufactured meta-materials. He has a PhD in structural engineering from the University of Illinois, where he was an NDSEG fellow focusing on the fracture mechanics of Al-Li alloys.

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