2025

MiNES

MATERIALS IN NUCLEAR ENERGY SYSTEMS

TMS
The Minerals, Metals & Materials Society

ANS®
American Nuclear Society

DECEMBER 7–11, 2025
Hilton Cleveland Downtown
Cleveland, Ohio, USA

PRELIMINARY
TECHNICAL PROGRAM

THANK YOU TO OUR SPONSORS

UK Atomic
Energy
Authority

LANYARD SPONSOR:

AMERICAN
ELEMENTS
THE MATERIALS SCIENCE MANUFACTURER®

www.tms.org/MiNES2025

Materials in Nuclear Energy Systems (MiNES) 2025 - High-Temperature Mechanical Behavior & Corrosion

Wednesday AM **Room: Center Street A**
December 10, 2025 **Location: Hilton Cleveland**
Downtown

Session Chairs: James Stubbins, University of Illinois; Marie Romedenne, Oak Ridge National Laboratory

---

8:00 AM Invited
Mechanisms-Based Creep-Fatigue Analysis of Alloy 617 for Advanced High-Temperature Nuclear Applications: Tamim Hossain[1]; Intisher Al-Tahmid Omi[1]; Mahmud Hasan Ovi[1]; Silvana Tabares Burgos[1]; Hoon Lee[1]; *James Stubbins*[1]; [1]University of Illinois Urbana-Champaign

The objective of this research is to quantify and model damage caused by creep-fatigue interactions in Nickel-based Alloy 617 at high-temperatures. The characterization of the performance depends on loading patterns, environmental factors, as well as microstructural evolution at various levels of "damage". With experimental investigations across a spectrum of stress levels, loading patterns and temperatures, we aim to develop a mechanisms-based approach for creep-fatigue analysis as the basis for extending the ASME allowable high temperature service limits. This methodology will enable extended service in advanced nuclear systems, where creep-fatigue represents a critical design limitation. Elevated temperature mechanical testing and the evolution of deformation microstructures will be supplemented by crystal plasticity modeling, to describe bulk deformation responses. This approach can be extended to component-level deformation analysis, marking a significant advancement beyond current analysis methods reliant on fatigue with hold-time protocols. Our study employs a novel approach, sequentially evaluating creep and fatigue loading, to better understand creep-fatigue interaction damage. Cyclic stress-strain tests at elevated temperatures coupled with Digital Image Correlation (DIC) are used to monitor stress concentration and relaxation during testing. Microstructural evolution has been performed to distinguish the separate and combined effects of creep and fatigue loading patterns. Thismethodology should be applicable for qualification of other high temperature structural alloys for nuclear applications.

8:30 AM
Metal-Water Oxidation Behavior of Niobium-Stabilized Austenitic Stainless Steel Under LOCA Conditions: *Juliana Nogueira*[1]; Natália Souza[1]; Fábio Camargo[2]; Claudia Motta[2]; [1]USP; [2]AMAZUL

This study investigated the behavior of niobium-stabilized austenitic stainless steel as an alternative material for nuclear fuel rod cladding under simulated LOCA (Loss of Coolant Accident) conditions, focusing on its oxidation resistance, ductility, and mechanical integrity at high temperatures (up to 1200 °C). Using ring compression test (RCT) and microstructural characterization techniques (i.e. SEM, EDS, and XRD), the research examined metal-water oxidation reaction after quenching, and the kinects of the oxide layer formation to address its limitations as a clad material. The niobium-stabilized austenitic stainless steel demonstrated superior post-exposure ductility and potential for PWR reactor applications, contributing to accident tolerant fuels and reliable energy technologies. The outcomes include quantifying oxidation rates, oxide layer thickness, post-quench mechanical strength, and direct performance comparisons with zirconium based alloys. This empirical research showed that the material had a superior perfomance during LOCA scenarios when compared with the traditional zirconium based alloys.

8:50 AM
Novel Al/Ti-Modified Ni-Mo-W-Cr Alloys for High Temperature Structural Applications in Molten Chloride Fast Reactors: *Sonali Ravikumar*[1]; Naveen kumar Nagaraja[1]; Boateng Twum Donkor[2]; Vishal Soni[1]; Vijay K Vasudevan[1]; Jie Song[3]; [1]University of North Texas; [2]University of Cincinnati; [3]Virginia Tech university

Molten chloride salts are promising advanced high-temperature (400-950°C) thermal energy storage (TES) and heat transfer fluid (HTF) materials in next generation nuclear power systems. Corrosion of structural alloys at these elevated temperatures remains a critical issue. While Ni-based alloys offer superior corrosion resistance than Fe-based alloys, none meet the combined requirements of high temperature strength, corrosion resistance, and irradiation tolerance for molten chloride fast reactors (MCFRs) operating at 700–950°C. The Ni-Mo-Cr alloys like Hastelloy C-276, C-22 and Ni-W-Cr alloys like Haynes-230 display better corrosion resistance and recent efforts have focused their further modification. This study aims to develop novel Ni-Mo-W-Cr-Al-Ti alloys for MSRs with an integrated computational materials engineering (ICME) approach involving thermodynamic simulations, alloy processing, microstructural characterization and performance testing. Alloys with varied Mo/W ratios and Al or Ti additions were synthesized, thermally aged (700–850 °C), and corrosion-tested in KCl-NaCl-$MgCl_2$ salt. Al/Ti-modified alloys showed significant hardness increase upon aging, attributed to γ'/γ'' precipitates and W/Mo-rich particles. Their corrosion resistance was comparable to commercial alloys, likely due to protective Al/Ti-rich oxide scales.To further optimize the microstructure, Mo concentration was systematically varied in Al/Ti-containing Ni-Cr-W-Mo alloys. Initial microstructure revealed equiaxed dynamically recrystallized grains, with hardness increasing with Mo content. Alloys exhibited formation of SRO and LRO structures, Ni2(MoCrW) and L12 phases, Mo/W-rich BCC particles and μ phases. The impact of varying Mo concentration in the presence of Al/Ti on ordered phase development and strengthening mechanisms will be discussed in the context of alloy optimization for structural use in MCFRs.

9:10 AM
Materials for Advanced Sodium Fast Reactors: Critical Assessment of Corrosion Resistance and Mechanical Integrity of Alumina-Forming Austenitic Alloys at 700 °C: *Marie Romedenne*[1]; Praneeth Bachu[1]; Tim Graening[1]; Caleb Massey[1]; [1]Oak Ridge National Laboratory

Advanced sodium fast reactors necessitate structural materials capable of maintaining mechanical integrity and corrosion resistance in chemically aggressive and thermally demanding environments of high temperature liquid sodium (Na) coolant. While legacy materials such as austenitic (316H, D9) and ferritic-martensitic (T91, HT9) alloys have demonstrated acceptable performance in previous Na-cooled reactor programs, their long-term mechanical and corrosion stability significantly deteriorates above 600 °C. This limitation has prompted the development of next-generation structural materials suited for elevated operating temperatures (≥650 °C). In this study, newly developed nanostructured alumina-forming austenitic (AFA) alloys were evaluated for their compatibility with static, commercially sourced liquid sodium at 700 °C for 1,000 hours. To assess the influence of oxygen impurities and the effectiveness of protective alumina scales, specimens were exposed both with and without pre-oxidation treatment. Room-temperature tensile specimens were used to evaluate the effect of sodium exposure on mechanical performance. Post-exposure characterization, including scanning electron microscopy (SEM), transmission electron microscopy (TEM), and compositional analysis, was conducted to examine corrosion scale formation, elemental redistribution, and substrate microstructural integrity. The results will provide insight into the role of surface oxide layers in mitigating corrosion and mass transfer, as well as the degradation in tensile properties resulting from high-temperature sodium exposure.