

NUCLEAR ENERGY RESEARCH INITIATIVE

Emissivity of Candidate Materials for VHTR Applications: Role of Oxidation and Surface Modification Treatments

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Program Area: Generation IV

Collaborators: None

Project Description

In this project, researchers propose to: 1) Evaluate emissivities of candidate materials (ferritic and austenitic alloys for the reactor pressure vessel (RPV) and internal components of the very high temperature reactor (VHTR) in air and helium environments at 300 to 900°C; 2) study the effects of surface treatments on the oxidation resistance of alloys by applying emerging and commercial surface treatments to candidate alloys and evaluating emissivities after exposure in air and helium environments at elevated temperatures; 3) develop a comprehensive understanding of the relationships between emissivity, oxide characteristics, and surface treatments by characterizing surface oxides that form on untreated and modified alloys after elevated temperature exposure; and 4) develop an integral separate-effects emissivity database for potential candidate materials and surface modification treatments.

The thermal radiation of heat from the outer surface will partially cool the RPV and internal components of the VHTR. With an unexpected increase in temperature, thermal radiation becomes a significant mode of heat dissipation because of its fourth power temperature dependence according to the Stefan-Boltzmann equation. Since oxidation will inevitably occur at these higher temperatures, it is clear that material emissivity is intricately related to the chemical, physical, and mechanical characteristics of the oxide scales that form on the surface, including their chemical composition, grain morphology, topography, and porosity. The growing field of surface modification provides opportunities for achieving high emissivities at high temperatures by changing topography and grain orientation or inducing controlled surface compositional changes.

Workscope

This project consists of the following primary tasks:

- Emissivity measurements of potential candidate materials before and after elevated temperature exposure in air and impure helium environments
- Characterization of oxide layers and the effect of oxide layer characteristics on emissivity
- Surface modification of alloys; emissivity testing and characterization of as-surface modified alloys and elevated temperature exposure in air and impure helium environments
- Emissivity measurements and surface characterization of surface modified alloys after high-temperature exposure to air and impure helium environments