NUCLEAR ENERGY RESEARCH INITIATIVE

Alloys for 1,000 °C Service in the Next Generation Nuclear Plant

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Collaborators: Special Metals Inc., Idaho National Laboratory, Oak Ridge National Laboratory

Project Number: 05-143

Related Program: Gen IV

Project Description

The objective of this project is to define strategies for improving alloys used for structural components in high-temperature helium reactors, such as the intermediate heat exchangers and primary-to-secondary piping. Specifically, the project will investigate oxidation/carburization from helium impurities, microstructural stability, and impact on creep behavior at temperatures between 900 and 1,000 °C. The aim is to better understand the synergisms among these critical processes and to provide data for long-term prediction of properties.

The design of the very high temperature reactor that has been selected by the Department of Energy for the Next Generation Nuclear Plant project calls for outlet gas temperatures of 1,000 °C. These are extremely challenging conditions for the operation of metallic components that will be required in the intermediate heat exchanger and primary-to-secondary piping. Inconel 617, an advanced nickel-based alloy, has been identified as the leading candidate for such applications. However, material properties in a high-temperature, impure helium environment are not sufficiently understood to qualify the alloy for service. Therefore, this study will also investigate alloy and microstructure modifications to enhance material properties**.**

Work Scope

Researchers will study surface oxidation and carburization reactions over a range of conditions in a system designed to precisely control levels of specific impurities (hydrogen, water, carbon dioxide, carbon monoxide, and methane) in a helium environment. Degradation of surface microstructure as a function of impurity, exposure times, and temperatures will be studied in detail. Researchers will also investigate the influence of impurity-induced surface degradation along with evolution of carbide and grain structure during creep deformation. The synergistic effects of these degradation mechanisms will be used to refine existing models for the prediction of creep behavior. Since it is likely that alloy improvements will be required to reach the goal of 1,000 °C operating temperature, researchers will also investigate alloying additions that are likely to improve carbide stability and/or influence diffusion and modification of the grain boundary structure through grain boundary engineering.