NUCLEAR ENERGY UNIVERSITY PROGRAMS

Bulk Nanostructured FCC Steels with Enhanced Radiation Tolerance

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Abstract

The objective of this project is to increase radiation tolerance in austenitic steels through optimization of grain size and grain boundary (GB) characteristics. The focus will be on nanocrystalline austenitic Fe-Cr-Ni alloys with an fcc crystal structure. The long-term goal is to design bulk nanostructured austenitic steels with enhanced void swelling resistance and ductility, and to enhance their creep resistance at elevated temperatures. The combination of grain refinement and GB engineering allows researchers to tailor the material strength, ductility, and resistance to swelling by 1) changing the sink strength for point defects, 2) increasing the nucleation barriers for bubble formation at GBs, and 3) changing the precipitate distributions at boundaries.

Void swelling was a limiting property preventing austenitic stainless steels from being adopted as a primary cladding and duct materials in fast reactor systems. This study will determine if researchers can use nanoscale grains to enhance void swelling resistance in austenitic alloys without any associated decrement in mechanical properties. Ultimately, a combination of nanoscale grains, optimized GB structures, and nanoprecipitates could lead to an austenitic steel with void swelling resistance comparable to ferritic-martensitic steels such as HT-9, but with the strength and ductility of 316 stainless steel. This project builds upon the success of nanoprecipitation strengthened steels, such as HT-UPS, by adding optimized grains and GBs. HT-UPS is expected to show enhanced void swelling resistance through the trapping of point defects at nanometer-sized carbides. The combined effects of nanograins and nanoprecipitates on radiation damage resistance in HT-UPS alloys will be explored in the final year of the project. Success may lead to a re-examination of the use of austenitic stainless steels in fast reactors for cladding and duct applications.