U.S. DEPARTMENT OF ENERGY
INTERNATIONAL NUCLEAR ENERGY RESEARCH INITIATIVE
DOE/ROK

ABSTRACT

Developing and Evaluating Candidate Materials for Generation IV Supercritical Water

Primary Investigator (U.S.): James I. Cole
Argonne National Laboratory (ANL)

Primary Investigator (Republic of Korea):
J. Jang, Republic of Korea Atomic Energy Research Institute (KAERI), and S.H. Hong, Republic of Korea Advanced Institute of Science and Technology (KAIST)

Collaborators: Republic of Korea Advanced Institute of Science and Technology, University of Michigan, Idaho National Engineering and Environmental Laboratory, University of Wisconsin

Project Number: 2003-008-K

Project Start Date: January 2003

Project End Date: December 2005

The goal of this project is to establish candidate materials for supercritical water reactor (SCWR) designs and to initiate the evaluation of the mechanical properties, dimensional stability, and corrosion resistance. To overcome the principal technical and scientific obstacles to the long-term future use of nuclear energy, new reactor designs must offer enhanced safety and reliability, sustainability and economics. To meet these goals, Generation IV (GEN IV) reactor designs must incorporate advanced materials for cladding and structural components. Currently, insufficient physical property data exist to qualify candidate materials. In many cases, candidate materials have not even been identified. For all GEN IV designs, significant materials property data must be obtained to license future reactor designs.

To meet the goals of the GEN IV Reactor research initiative, international collaborations are critical in terms of shared resources and shared expertise. Because of the significant costs associated with nuclear systems research an international cost sharing approach will provide maximum value for the limited research dollars. Both the Republic of Korea (ROK) and the United States (US) have a shared interest in the development of advanced reactor systems that employ supercritical water as a coolant.

SCWRs are one of the more promising GEN IV nuclear systems concepts due to enhanced thermal efficiencies and relative compactness when compared to current light water reactor (LWR) technology. The relatively mature alloy development programs for supercritical fossil plants (SC-FP) can be used as a baseline for the development of fuel cladding and structural materials in a SCWR. The SC-FP alloys have known corrosion resistance properties but have not been evaluated relative to degradation in radiation fields. Additionally, materials developed for the fast reactor programs, which operated in similar temperature regimes as SCWR, will also be evaluated for SCWR applications. These alloys have known radiation resistance, but the corrosion performance is unknown. To understand the relative materials compatibility, a comprehensive research program is proposed that initially evaluates state-of-the-art SC-FP and fast reactor materials for application in SCWR, and expands on these alloys to produce materials optimized for SCWR fuel cladding and core internal structures.

2003-008-K (continued)

An integrated research program involving Argonne National Laboratory (ANL), The University of Michigan (UM), The Idaho National Engineering and Environmental Laboratory (INEEL), the University of Wisconsin (UW), Korea Atomic Energy Research Institute (KAERI), and Korea Advanced Institute of Science and Technology (KAIST) is proposed to advance goals of the SCWR concept and to aid in the removal of technical barriers regarding fuel cladding and reactor core internals performance. The program will focus on the selection and qualification of advanced materials for SCWR applications. Three materials classes will be investigated, 1) ferritic and ferritic-martensitic steels, 2) austenitic alloys 3) and developmental alloys such as oxide dispersion strengthened (ODS) alloys, nanocrystalline alloys, and grain boundary engineered alloys.

The research program will comprise three phases, with the findings of each phase constituting a deliverable which can be readily disseminated to organizations involved in the design and development of the SCWR concept as well as other reactor concepts where advanced high temperature alloys are required. Phase I of the project will involve a comprehensive literature search to identify the most promising candidate alloys for further investigation. In Phase II of the project, each of candidate alloys will be evaluated in terms of high temperature creep strength, stress corrosion cracking susceptibility, radiation stability and weldability. Finally, the third phase of the project will provide material recommendations and an overall reactor irradiation plan for future GEN IV programs. Although this project will not be able to perform a complete qualification of materials for SCWR application, it will generate data to support a recommendation of prime candidate materials for further evaluation and inreactor testing.