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Reactor Physics Studies for the AFCI RACE Project: Reactor-Accelerator Coupling Experiments Project: Quarterly Progress Report January-March 2006

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Reactor Physics Studies for the AFCI RACE Project (Reactor-Accelerator Coupling Experiments Project)

Quarterly Progress Report
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UNLV Transmutation Research Project Task 27
Principle Investigator: Denis Beller, Ph.D.

Purpose and Problem Statement

In the RACE Project of the U.S. Advanced Fuel Cycle Initiative (AFCI), a series of accelerator-driven subcritical systems (ADSS) experiments is being conducted at the Idaho State University's Idaho Accelerator Center (ISU-IAC) and at the University of Texas (UT) at Austin, and will be conducted at the Texas A&M University. In these experiments electron accelerators are used to induce bremsstrahlung photon-neutron reactions in heavy-metal targets; this source of 10^{10} to 10^{13} n/s initiates fission reactions in the subcritical systems. These systems include a compact, transportable assembly at ISU and TRIGA reactors at UT-Austin and Texas A&M. These experiments will provide a variety of cores, fuel types and enrichments, and target/reactor configurations for many separate accelerator coupling studies. The UNLV portion of this project will be a three-year, three-phase project employing a principal investigator (as well as the UNLV TRP RACE Project Director), a graduate student, and undergraduate students to support computational and experimental research at the ISU and the Texas universities, to integrate the UNLV Transmutation Research Project with this accelerator-driven transmutation research, and to further develop UNLV's computational infrastructure for reactor physics research.

Personnel

Principle Investigator: Research Prof. Denis Beller, Department of Mechanical Engineering, UNLV.

Students: Mr. Evgeny Stankovskiy, graduate student, Department of Mechanical Engineering, came to UNLV from the Institute of Nuclear Power Engineering in Obninsk, Russia, to pursue a doctorate. He will design, conduct, and analyze an accelerator-driven subcritical experiment at Idaho State University. Mr. Timothy Beller, Mr. Brice Howard, and Mr. Ryan LeCounte, undergraduate students in the Department of Mechanical Engineering, conducted an undergraduate design study in support of future high-power experiments in a TRIGA reactor.

UNLV Graduate Student Thesis Advisor: Prof. Robert Boehm, Department of Mechanical Engineering, UNLV.

National Laboratory Collaborator: Dr. George Imel, Argonne National Laboratory (former director of experiments in the MUSE and TRADE programs in Europe).

DOE Collaborator: Dr. Thomas Ward, TechSource, Inc. (UNLV Russian Collaboration Science Adviser)

Summary Report October-December 2005:

M.E. undergraduate students Ryan LeCounte, Brice Howard, and Timothy Beller continued a two-semester senior design project to design, construct, and test a new high-power, uranium-containing water-cooled target for Texas RACE. They have dubbed the target the Cooled Electron Target--Optimized for Neutron Production, or CETON. During the second semester, after analyzing and constructing a prototype of a compact version of CETON, they determined that a design change was needed. The new design includes a tungsten electron-photon converter, an aluminum cooling shroud, and a cavity for inserting an aluminum-clad natural uranium photon-neutron converter. They sized the cavity for natural uranium rods being transferred from Rensselaer Polytechnic Institute to Idaho State University. They also acquired and installed the FLUENT® CFD code, then used it to begin analysis of cooling of the high-power target. The students then completed the final design of the high-power target and initiated purchasing and fabrication of components. The aluminum body and spacers were fabricated in the UNLV College of Engineering machine shop, and tungsten-copper (80% tungsten) disks were machined at the Idaho Accelerator Center. The CETON was assembled and successfully leak tested with high-pressure water. Additional testing to measure neutron generation and heat transfer while coupled to a 25-MeV electron linac will be conducted at ISU's IAC in April.

Figure 1. Components of the CETON (Cooled Electron Target--Optimized for Neutron production) excluding tungsten-copper disks for converting electrons to photons. The W-Cu disks fit in the cavity at the upper left. In addition, the body is bored to accept a 10" aluminum-clad uranium photo-neutron generator.

Ph.D. student Evgeny Stankovskiy is evaluating a variety of code systems for modeling neutron generation and transport and thermal feedback effects in accelerator-driven TRIGA as well as other reactors. The group considered ERANOS, RELAP, PARCS, and APOLLO. The group has the INL's RELAP5 code system for thermal-hydraulic reactor analysis, and the ERANOS reactor analysis code was recently received from the CEA (France). EUROTRANS/ECATS participants are developing accelerator-driven applications of ERANOS, and RACE collaborators at University of Michigan have used it to evaluate TRADE and MUSE experiments. Because of evolution of DOE priorities, the UNLV RACE research has been refocused to concentrate on the testing of the high-power target and on conducting and analyzing ADS Experiments at ISU. Unless substantial funding is found for UT and/or Texas A&M, UNLV will not participate in Texas RACE except in the design of the target for high-power RACE in 2007.

Three students attended a MCNPX class at UNLV offered by Los Alamos National Lab.
In his role as national RACE Project Director, the PI continued to coordinate activities of several universities and several European organizations to contribute to target and experiment designs for High-Power RACE. Currently an international meeting of this group in April is being planned.

Publications:

"High-Power Accelerator Target Design for the AFCI RACE Project," T. Beller, B. Howard, R. LeCounte, and D. Beller, full paper submitted for publication in the *Proceedings of the 2006 International High Level Radioactive Waste Management Conference* (Las Vegas, Nevada, April 30-May 4, 2006).

Overview of the AFCI Reactor-Accelerator Coupling Experiments (RACE) Project, D. Beller, *Proceedings of the Eighth Information Exchange Meeting on Actinide and Fission Product Partitioning & Transmutation*, OECD/NEA, Paris, France, pp 495-504 (2005).

Initial Results from the AFCI Reactor-Accelerator Coupling Experiments (RACE) Project, D. Beller, A. Hunt, J. Bennion, M. Reda, K. Sabourov, R. Spaulding, and K. Folkman, *Proceedings of the Eighth Information Exchange Meeting on Actinide and Fission Product Partitioning & Transmutation*, OECD/NEA, Paris, France, pp 699-710 (2005).