Matching Grant to Support Nuclear Engineering Education At Georgia Tech

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Final Report for 2001 DOE Matching Grant Program

During the 2001 Fiscal year, funds from the DOE Matching Grant Program, along with matching funds from the industrial sponsors have been used to support both research (in the area of thermal-hydraulics) and educational missions. Experimental research has been performed in the area of axial offset anomaly in pressurized water reactors. Numerical research has also been performed in the area of multi-fluid modeling of two-phase flow. Details of activities in these two areas are given below. As for the educational component, funds were used to support the Georgia Tech Nuclear and Radiological Engineering (NRE) Scholarship Program. This Scholarship Program has allowed Georgia Tech to substantially increase the freshman class size and to populate it with outstanding students.

A. Axial Offset Anomaly in Pressurized Water Reactors

Axial offset anomaly (AOA) in pressurized water reactors refers to the presence of significantly larger negative axial offset deviation than predicted by core design calculations. The neutron flux depression in the upper half of high power rods experiencing significant subcooled boiling is believed to be caused by the concentration of boron species within the crud layer formed on the cladding surface. Recent investigations of the root cause mechanism for AOA suggest that boron build-up on the fuel is caused by precipitation of lithium metaborate within the crud in regions of subcooled boiling. Indirect evidence in support of this hypothesis was inferred from operating experience at Callaway and other PWRs, where lithium return and hide-out were, respectively, observed following power reductions and power increases when AOA was present. However, direct evidence of lithium metaborate precipitation within the crud could not be obtained from plant data because of its retrograde solubility. To this end, an experimental test facility, hereinafter referred to as the Georgia Tech AOA Test Facility (Figure 1), was designed, constructed, and operated at Georgia Tech. The aim was to directly verify the presence, or absence, of lithium metaborate in the crud layer of a boiling heat transfer surface under prototypical PWR conditions, when AOA would be expected. Partial funding for instrumentation and test facility upgrades were provided by this program. Funds required for operation of the test facility, including salary support for research staff and graduate students, have been secured through an EPRI-funded research contract. The ability to construct and upgrade the AOA test facility through this Industry Matching program has directly impacted our ability to attract additional research funds from the nuclear industry to understand and solve this complex PWR operational issue faced by nuclear utilities. Research effort in this area has introduced our graduate students to a wide array of state-of-the-art instrumentation and analysis techniques, including SEM-EDX, XRD, SIMS, and ICP-MS. Familiarity with these techniques has significantly enhanced our students' knowledge and ability to utilize advanced analytical techniques in a wide array of research problems.

B. Multi-Fluid Modeling of Two-Phase Flow of Steam Conditioning Equipment

The increased emphasis on improved reliability, flexibility, and efficiency in commercial and utility power plants has produced considerable attention to system performance. Integral to such performance is the operation of devices used for proper conditioning of steam temperature. These devices normally utilize spray of subcooled water to regulate or control the temperature

of superheated steam. Despite their widespread application, design of such systems has heretofore been essentially empirical. Without fundamental understanding of the various transport processes involved, prediction of system performance and accurate temperature control for the various operating conditions would be highly uncertain. More importantly, without such fundamental understanding design advances could not be systematically evaluated before introducing them in the field. To this end, a research program has been undertaken to allow mechanistic modeling of the various transport processes taking place in such system. The research was strongly supported by the industrial partners in the matching grant program. Efforts have been focussed on the development of detailed transient three-dimensional computer codes which allow mechanistic modeling of such systems using actual geometries with a wide range of operating conditions. Efforts have also been focussed on validating the computer models by comparing model predictions to actual data. A 35 MW Co-generation plant at the University of North Carolina-Chapel Hill was equipped with detailed instrumentation to measure the detailed steam temperature distributions downstream of a full-size desuperheater unit. The system was independently modeled using the computer codes developed at Georgia Tech. Comparison between the code predictions and actual data corresponding to system operation during both summer and winter conditions has been made with excellent agreement.

C. NRE Scholarship Program

Using funds provided by our industrial sponsors and by the DOE Matching Grants Program, the NRE Program has awarded \$2000 (\$1000 per semester) merit scholarships to incoming freshmen. For the Autumn 2001 recruiting class, we were able to award about 75% of our incoming class with such scholarships. As one of the key components to a new recruiting effort begun two years ago, we have increased our incoming freshman class size from about 10 per year to 28 in Autumn 2001. In addition, we have increased the fraction of students that attend Georgia Tech with NRE as their major after being admitted has been increased from about 30% to about 70%. By maintaining this NRE Scholarship Program over the next several years, it anticipated that the incoming freshman class size will increase to about 40 per year and the NRE Program will have over 100 undergraduates in it. Consequently, we believe that the Matching Grant Program has been an essential element in reviving the undergraduate NRE Program at Georgia Tech by allowing industrial sponsors to double the "bang for their buck." The industrial sponsorship has had additional benefits as well. During our Annual NRE Scholarship Reception, the sponsors all attend. This provides a valuable means of interacting with the students and faculty.

Figure 1: Georgia Tech AOA Test Facility