U.S. DEPARTMENT OF ENERGY
NUCLEAR ENERGY RESEARCH INITIATIVE
ABSTRACT

PI: **Vijay Dhir** **Proposal No.: 99-0134**

Institution: **University of California, Los Angeles**

Collaborators: **None**

Title: **Complete Numerical Simulation of Subcooled Flow Boiling in The Presence of Thermal and Chemical Interactions**

At present, guidelines for fuel cycle designs to prevent axial offset anomolies (AOA) in pressurized water reactor (PWR) cores are based on empirical data from several operating reactors. Although the guidelines provide an ad-hoc solution to the problem, at present a unified approach based on simultaneous modeling of thermal-hydraulics and chemical and nuclear interactions with vapor generation at the fuel cladding surface does not exist. As a result, the fuel designs are overly constrained with a resulting economic penalty. If, on the other hand, less constrained designs are developed, the possibility of occurrence of AOA exists. The objective of the proposed work is to develop a complete numerical simulation model supported by laboratory experiments that can be used for fuel cycle design with respect to thermal duty of the fuel to avoid economic penalty, as well as, AOA.

In carrying out the proposed work, a building block type of approach is used. Starting with a complete numerical simulation of inception, growth and departure of a single bubble subjected to forced flow of subcooled liquid parallel to the heater surface, the complexity will be increased to include bubble-bubble interactions at, and adjacent to, the heated surface. The modeling of temperature and chemical concentration fields adjacent to the heated surface will be an integral part of the simulations. The simulations will not only provide a mechanistic basis for the partitioning of the heat flux during subcooled boiling at the heated surface, but also the conditions that can lead to precipitation of boron in the crud.

Experiments on both a flat plate heater and a 9-rod bundle will be carried out to validate the results of numerical simulations. Microfabrication techniques will be used to prepare the flat plate heater, so that number density of cavities that nucleate on the surface can be controlled. In the experiments, liquid subcooling, flow velocity concentrations of boron and lithium, wall heat flux, and system pressure will be varied parametrically. Flat plate experiments will be conducted up to 20 atm. pressure, whereas the maximum pressure in the bundle experiments will be 5 atm. The purpose of the rod bundle experiments is to delineate the effect of heater geometry and any differences that may exist between a designed and a commercial surface. After the numerical simulations have been validated with respect to pressure, the results will be extended to system pressures typical of a PWR.

The validated results will be cast in a form so that they can be easily incorporated into a systems code that contains a neutronic package and can be used for analysis of AOAs.