

Thesis Defense

*The following four Nuclear Engineering students will defend their Thesis next
Thursday, November 19 in the ME Conference Room.*

Student: **Thomas Curtis**

Time: **9:00 am**

Title of Thesis: Nuclear Fuel Requirements for the American Economy – A Model

Committee: Dr. Knight – Advisor

Dr. Kaoumi – Second Reader

Graduate Studies Representative: Dr. Reynolds

Abstract

A model is provided with default and user-selectable choices for American energy requirements applicable to nuclear power, reactor operation and new builds, and nuclear fuel sources. The model can extend through 2099. It enables rapid comparison of scenarios including some interactive effects. Outputs include annual energy provided by nuclear reactors, the number of reactors, requirements for natural Uranium and other fuel sources, and the depleted Uranium and spent fuel generated. Energy demand, including electricity and hydrogen, is obtained from US DOE historical data and projections, along with other studies of potential hydrogen demand. An option to include other energy demand to nuclear power is included. Reactor types modeled include (thermal reactors) PWRs, BWRs and MHRs and (fast reactors) GFRs and SFRs. The MHRs (VHTRs), GFRs and SFRs are similar to those described in the 2002 DOE "Roadmap for Generation IV Nuclear Energy Systems." Fuel sources include natural Uranium, down-blended HEU, surplus military Plutonium, self-recycled spent fuel (1 pass), LWR spent fuel as fuel for other reactors, Plutonium from breeder reactors and depleted Uranium. Other reactors and fuel sources can be added to the model. Fidelity checks of the model's results indicate good agreement with historical Uranium use and number of reactors, and with DOE projections to 2030. The model supports conclusions that substantial use of natural Uranium will likely continue to the end of the 21st century, though legacy spent fuel and depleted uranium could easily supply all nuclear energy demand by shifting to predominant use of fast reactors.

Student: **Jerome Geathers**

Time: **10:00 am**

Title of Thesis: Characterization of Uranium Carbide microspheres in an inert Zirconium Carbide matrix for Gas Fast Reactors

Committee: Dr. Knight – Advisor

Dr. Roberts – Second Reader

Graduate Studies Representative: Dr. Reynolds

Abstract

The characterization of an advanced nuclear fuel for Gas Fast reactors has been studied. Portions of a dispersion/composite fuel involving Uranium Carbide (UC) microspheres and in a Zirconium Carbide (ZrC) have been characterized and studied. Uranium carbide (UC) microspheres produced in the USC-Nuclear Materials Laboratory were subjected to metallographic techniques, and then characterized by analytical methods. A method for separation of spherical and non-spherical microspheres was developed involving an inclined plane. Quantitative analysis and imagery were gathered using scanning electron microscopy (SEM), back scattering electron microscopy (BSE), electron microprobe for quantitative analysis (EPMA), and x-ray photoelectron spectroscopy (XPS). X-ray diffraction (XRD) was also used to find the crystal structure of the microspheres. The UC microspheres were further investigated by annealing to homogenize the as-produced dendritic microstructure. The annealing process was completed using a high temperature tube furnace at a temperature of 1650°C in an inert argon atmosphere. The results of the annealing experiment were analyzed using the same methods of microscopy and microanalysis. Uranium diffusion from the kernels into the ZrC matrix was studied to understand the interface that is developed during the brief but high temperature fabrication process. Uranium diffusion into the matrix was confirmed through EPMA and supported by diffusion calculations.

Student: **Jonathan DeGange**

Time: **11:00 am**

Title of Thesis: Analysis of u-zr-c-o quaternary system for applications in advanced zrc coated triso particles

Committee: Dr. Knight – Advisor

Dr. Roberts – Second Reader

Graduate Studies Representative: Dr. Rocheleau

Abstract

The implementation of ZrC for use in oxide TRISO particles for Very High Temperature Reactor (VHTR) conditions to prevent kernel overpressurization and kernel migration is evaluated. Analyses were performed incorporating first-principles thermodynamics along with out-of-pile experimental work. UO_{2+x} - U_4O_9 powders are created and used for in-vacuo thermogravimetric testing with both carbon and zirconium carbide powders to evaluate the efficiency of ZrC for usage as an oxygen getter in oxide TRISO fuels.

Student: **Dennis Gehr**

Time: **12:00 pm**

Title of Thesis: The Effect of Coating Parameters on Advanced TRISO Fuels with Zirconium Carbide

Committee: Dr. Knight – Advisor

Dr. Roberts – Second Reader

Graduate Studies Representative: TBD

Abstract

Recent studies of TRISO fuel behavior have shown a number of problems with the conventional SiC TRISO coating system at very high temperature, not unlike the temperatures obtainable in the very high temperature reactor (VHTR) design. These problems include but are not limited to over pressurization of the kernel due to fission gas buildup as well as kernel migration, in the presence of a temperature gradient, known as the amoeba effect. To negate these problems a solution of adding a ZrC gettering layer between the kernel and PyC buffer layer has been proposed. The purpose of this study is to provide insight into the coating parameters and how they affect the coating properties. Advanced TRISO coatings consisting of a ZrC getter are applied to surrogate kernels which represent the oxide fuel kernel of a VHTR. The coatings are then analyzed via optical and electron microscopy techniques to visually verify coating integrity. Further analysis is done using XRD to confirm that ZrC has been deposited. Density measurements are performed using a helium pycnometer to ensure coating densities meet or exceed 95% theoretical density.