CHARACTERIZATION OF ALPHA-PHASE SINTERING OF URANIUM AND URANIUM-ZIRCONIUM ALLOYS FOR ADVANCED NUCLEAR FUEL APPLICATIONS

A Thesis Proposal

by

GRANT W. HELMREICH

Submitted to the Office of Graduate Studies of

Texas A&M University

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2010

Major Subject: Nuclear Engineering

Characterization of alpha-phase sintering of uranium and uranium-zirconium alloys for advance nuclear fuel applications.

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Head of Department, Raymond Juzaitis

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ABSTRACT

Characterization of Alpha-Phase Sintering of Uranium and Uranium-Zirconium Alloys for Advanced Nuclear Fuel Applications. (December 2010)

Grant W. Helmreich, B.S. Nuclear Engineering; B.A. Chemistry, Texas A&M University

Chair of Advisory Committee: Dr. Sean M. McDeavitt

The sintering behavior of uranium and uranium-zirconium alloys in the alpha phase were characterized in this research. Metal uranium powder was produced from pieces of depleted uranium metal acquired from the Y-12 plant via hydriding/dehydriding process. The size distribution and morphology of the uranium powder produced by this method were determined by digital optical microscopy.

Once the characteristics of the source uranium powder were known, uranium and uranium-zirconium pellets were pressed using a dual-action punch and die. The majority of these pellets were sintered isothermally, first in the alpha phase near 650°C, then in the gamma phase near 800°C. In addition, a few pellets were sintered using more exotic temperature profiles. Pellet shrinkage was continuously measured in situ during sintering.

The isothermal shrinkage rates and sintering temperatures for each pellet were fit to a simple model for the initial phase of sintering of spherical powders. The material specific constants required by this model, including the activation energy of the process, were determined for both uranium and uranium-zirconium.

Following sintering, pellets were sectioned, mounted, and polished for imaging by electron microscopy. Based on these results, the porosity and microstructure of the sintered

pellets were analyzed. The porosity of the uranium-zirconium pellets was consistently lower than that of the pure uranium pellets. In addition, some formation of an alloyed phase of uranium and zirconium was observed.

The research presented within this thesis is a continuation of a previous project; however, this research has produced many new results not previously seen. In addition, a number of issues left unresolved by the previous project have been addressed and solved. Most notably, the low original output of the hydride/dehydride powder production system has been increased by an order of magnitude, the actual characteristics of the powder have been measured and determined, shrinkage data was successfully converted into a sintering model, an alloyed phase of uranium and zirconium was produced, and pellet cracking due to delamination has been eliminated.

DEDICATION

This thesis is dedicated to my grandmother, who first taught me to love learning.

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NOMENCLATURE

TRU	Transuranics
DU	Depleted Uranium
EBR II	Experimental Breeder Reactor II
IFR	Integral Fast Reactor
LVDT	Linear Variable Differential Transformer
SEM	Scanning Electron Microscope
BSE	Backscatter Electron
WDS	Wavelength Dispersive Spectroscopy

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