HIGH THERMAL CONDUCTIVITY UO_2-BeO NUCLEAR FUEL: NEUTRONIC PERFORMANCE ASSESSMENTS AND OVERVIEW OF FABRICATION

A Thesis

by

MICHAEL JAMES NARAMORE

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

August 2010

Major Subject: Nuclear Engineering

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Approved by:

Co-Chairs of Committee,	Sean M. McDeavitt
	Jean C. Ragusa
Committee Members,	Karen Vierow
	Miladin Radovic
Head of Department,	Raymond J. Juzaitis

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ABSTRACT

High Thermal Conductivity UO_2-BeO Nuclear Fuel: Neutronic Performance Assessments and Overview of Fabrication. (August 2010)

Michael James Naramore, B.A., Texas A&M University

Co-Chairs of Advisory Committee, Dr. Sean M. McDeavitt
Dr. Jean C. Ragusa

The objective of this work was to evaluate a new high conductivity nuclear fuel form. Uranium dioxide (UO_2) is a very effective nuclear fuel, but it's performance is limited by its low thermal conductivity. The fuel concept considered here is a ceramic-ceramic composite structure containing UO2 with up to 10 volume percent beryllium oxide (BeO). Beryllium oxide has high thermal conductivity, good neutron moderation properties, neutron production from an (n,2n) reaction, and it is chemically stable with uranium at high temperatures. The UO2-BeO fuel concept employs a continuous lattice of BeO within the microstructure of the fuel in order to significantly increase the thermal conductivity of the fuel.

In order to better understand the effect of this fuel concept on reactor operations 2D infinite lattice neutronic simulations for a typical pressurized water reactor fuel assembly were performed using the code DRAGON. Parametric analysis of the beginning of cycle (BOC) effect of BeO and its corresponding temperature increase revealed that the introduction of 5% by volume BeO into UO2 fuel results in a ~400 pcm increase in BOC reactivity, while the 100 K temperature decrease with the introduction of 10% by volume BeO increased the BOC reactivity by ~350 pcm. Cycle length estimates for a PWR were performed with three and four-batch cycles while keeping the uranium-235 mass constant and the introduction of 10% by volume BeO was found to have a ~20 day

increase in reactor operation, a 4000-5000 MWd/tHM increase in burnup, and a 2800-2900 pcm increase in BOC reactivity.

A portion of the work documented here includes the establishment of a UO_2-BeO fabrication method with the necessary equipment. The description of a processing vessel is provided and the step-by-step procedures for fabrication are described. The processing vessel has a linear variable differential transducer equipped in order to characterize the sintering behavior.

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TABLE OF CONTENTS

Page

Page

Page