INL/CON-06-01123
PREPRINT

Thermal Analysis of LWR-2 Experiment in the Advanced Test Reactor

American Nuclear Society Annual Meeting

Grant L. Hawkes

June 2006

Thermal Analysis of LWR-2 Experiment in the Advanced Test Reactor

Grant L. Hawkes

Idaho National Laboratory: 2525 Fremont / P.O. Box 1625, Idaho Falls, Idaho, 83415, grant.hawkes@inl.gov

INTRODUCTION

A thermal analysis was performed at the Idaho National Laboratory on the Light Water Reactor (LWR-2) experiment fuel to determine fuel temperatures and safety margins in the Advanced Test Reactor (ATR).

The overall experiment description and various types of fuel proposed for this experiment is presented Reference [1].

The purpose of this paper is to present the thermal analysis for the U.S. Department of Energy (DOE) Advanced Fuel Cycle Initiative's LWR-2 irradiation experiment in the ATR.

MODEL DESCRIPTION

The LWR-2 experiment will utilize the test geometry and hardware designed for the weapons-grade MOX disposition program. A three- dimensional (3-D) representation of the fuel pin geometry is shown in Figure 1.

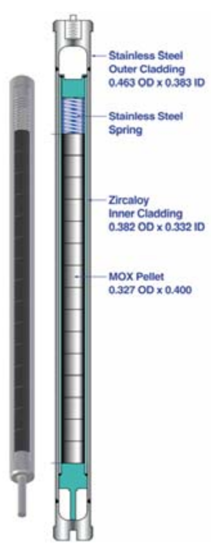

Fig. 1. 3-D cross-sectional view of LWR-2 fuel pin.

An axi-symmetric model was created with the radii of the different materials adjusted to have the same cross-sectional area as in the real 3-D experiment. Figure 2 shows the finite element mesh used in the model. There are approximately 28,000 nodes and 21,000 elements in the model.

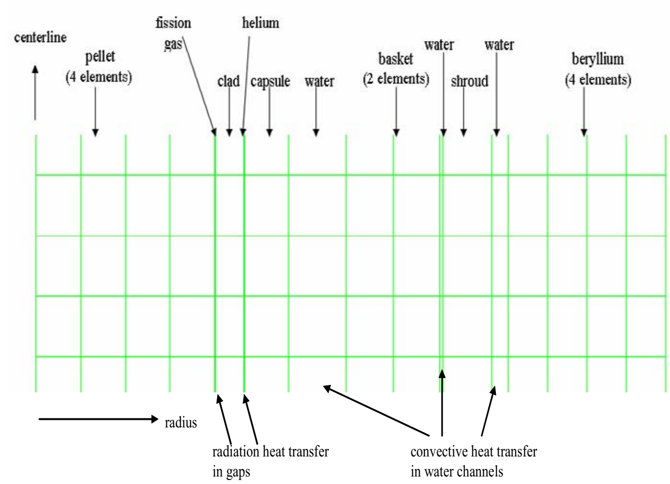

Fig. 2. Axi-symmetric finite element mesh.

Two finite element models were created for this analysis. The commercial finite element and stress analysis package ABAQUS [2] was used. The thermal properties came from Reference [3]. The heat rates were calculated with the nuclear physics code MCNP [4]. The water flow rates were taken from Reference [3]. The purpose of this first model was to calculate the water temperature as a function of axial height as it flows through the basket. The second model created is known as a "coupled thermal-stress" model in ABAQUS.

Water temperatures from the first model varying with axial location were input into this second model as a film coefficient temperature. Gap conductance heat transfer was also included in this second model.

RESULTS

Results of this experiment are shown in Figure 3. The maximum temperature for this capsule is 1,790 K. Future plans call for this capsule to be moved to the back and placed on either the top or bottom. This will shield it from the neutron source of the driver fuel of the ATR core with a smaller fission power density capsule. Figure 3 shows the centerline temperature for each column of capsules in the basket.

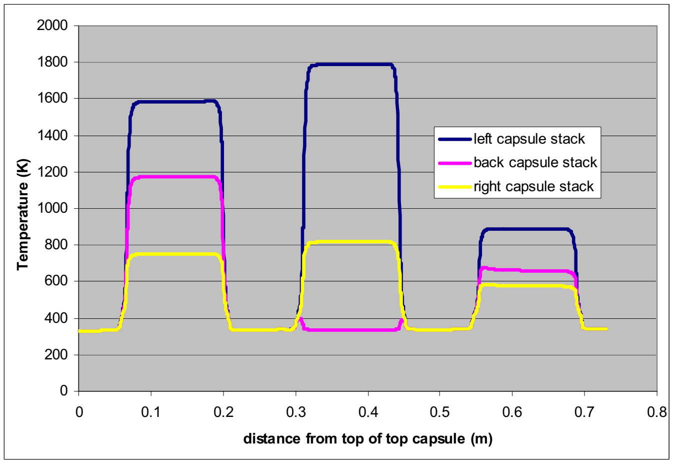

Fig. 3. Capsule fuel centerline temperatures.

REFERENCES

1. J. Carmack and D. Utterbeck, "Light Water Reactor Transmutation Fuel Irradiation Experiment (LWR-2)," ANS Summer Conference, San Diego, California, June 2005.

2. ABAQUS User's Manual Version 6.2, ABAQUS Inc. Pawtucket, Rhode Island, 2003.

3. L. J. Ott, "Thermal/Hydraulic Caluclations for Phase IV of LWR MOX Irradiation Average-Power Test," ORNL/MD/LTR-191, July 2000.

4. R. L. Moore, et al., MOCUP: MCNP-ORIGEN2. Coupled Utility Program, INEL-95/0523, Idaho National Engineering Laboratory, September 1995.

Acknowledgement

Work supported by the U.S. Department of Energy, Office of Office of Nuclear Energy, Science, and Technology (NE), under DOE-NE Idaho Operations Office Contract DE-AC07-05ID14517.