Investigation of Thermal Contact Gas Gap Conductance Using COMSOL Multiphysics®

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Abstract

Introduction: Our safety analysis group in the Research Reactors Division (RRD) of Oak Ridge National Laboratory (ORNL) have been supporting a research project to investigate the production of Pu-238 isotope for the National Aeronautics and Space Administration (NASA) to support missions of deep space travel in the High Flux Research Reactor (HFIR). COMSOL Multiphysics® has been used to support this activity in the past [1], and we now have successfully installed and irradiated three different target designs. We expect to use COMSOL to analyze and irradiate additional target designs in the near future and eventually produce many irradiated targets.

Use of COMSOL Multiphysics: COMSOL version 4.3b was recently released with a new thermal contact feature to directly model gas-gap conductance. Prior to v4.3b, our analysis has involved the programming of variables and functions within the COMSOL model tree in order to account for gas-gap conductance following the methods documented by Madhusudana [2]. Therefore, this new thermal contact feature not only could provide a less difficult model to create, but it could potentially improve on the accuracy and stability of the final model. The gas-gap conductance is responsible for the dominate effect on the temperature change within the irradiated target assembly being analyzed. The maximum temperature is the limiting criteria for how much material can be irradiated, and what location within the HFIR the target can be placed and receive maximum flux and isotope production. Hence, it is possible that this new feature could produce improvements in both quality and quantity of the product for our customer.

This paper documents our comparison between our established method of accounting for the gas-gap conductance. We compare the equations used for the present method with the method given in COMSOL v4.3b. We also compare the predicted results of the two methods, and attempt to describe the cause for any differences between the two methods. And finally, suggested improvements in either method are proposed.

Results: We will document the difference between the results obtained from existing COMSOL models to results obtained using the new thermal contact model of version 4.3b. A typical existing result for axial temperature distribution for a partially-loaded Pu-238 target in HFIR is shown in Figure 1.

Conclusion: If the results from the new thermal contact model in version 4.3b are acceptable, we anticipate switching to the this new method of analysis.

Reference

[1] J. D. Freels, P. K. Jain, R. W. Hobbs, Design and Nuclear-Safety Related Simulations of Bare-Pellet Test Irradiations for the Production of Pu-238 in the High Flux Isotope Reactor using COMSOL, Proceedings-COMSOL Conference Boston 2012, October 2012.

[2] C. V. Madhusudana, Thermal Contact Conductance, Springer-Verlag, ISBN 0-387-94534-2, 1995.

Figures used in the abstract

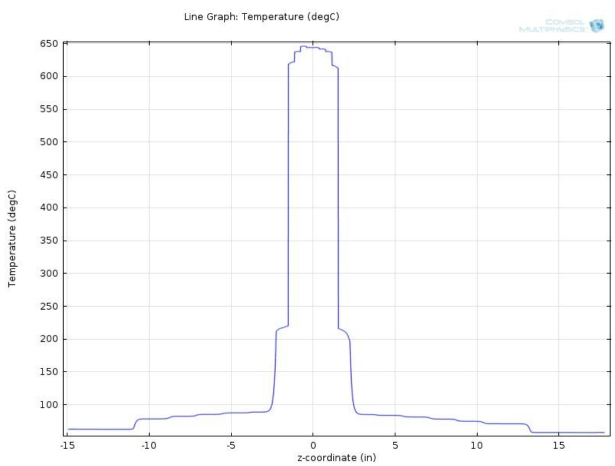

Figure 1: Temperature vs. axial position along the axial centerline for the 900°C Pellet at the end of one irradiation cycle at the safety-basis conditions of 130% power.