Key Input Variables for RIA Simulations: A Study Based on FRAPCON and SCANAIR Codes

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Recent trends in the use of nuclear fuels have raised the need of enlarging simulation capabilities to high burn-up fuels. In particular, modeling of the thermo-mechanical behavior of a fuel rod during a Reactivity Insertion Accident (RIA) is a challenging issue that requires development of specific transient codes, such as SCANAIR or FRAPTRAN, as well as the extension to high burn-up scenarios of irradiation codes, as FRAPCON-3.

Accuracy of a transient code response depends largely upon variables and parameters given in its input deck, some of which come from the output of an irradiation code. It is foreseeable, however, that not all the information transferred from the steady state code to the transient one has the same relevance for its performance.

The main goal of this paper is to identify key parameters and variables and to quantify their effect in the simulation. Two major benefits could be drawn from this work. On one side, a major emphasis could be given to investigate the impact of uncertainties affecting those key magnitudes on code estimates when simulating RIA scenarios. On the other, attention of steady state code developers might be focused on improving those models related to prediction of those important variables.

The code interface analyzed in this paper is the one linking FRAPCON-3 and SCANAIR codes. The former has been developed by PNNL and is presently been extended and validated. The latter is under development by IRSN (supported on the CABRI project) and consists in three highly coupled modules: thermodynamics, fission gas behavior and structural mechanics. The experimental scenario taken as a reference has been the CIP02 test of the CABRI project.

Once the variables transferred from FRAPCON to SCANAIR were listed, each of them was given an uncertainty range and the maximum variation of each one was explored. The results sensitivity was assessed through examining output magnitudes of SCANAIR, some of a thermal nature (i.e., coolant and fuel temperature and enthalpy) and others of a mechanical one (clad elongation, hoop strain and strain energy density). The study has indicated that input variables might be split in two groups: “hard” and “soft” ones. Hard variables do effect drastically code estimates, either thermally and/or mechanically; hardness parameter, gap width and the so-called rim burst option are good examples of this group. Soft variables slightly affect code predictions; some of them are burn-up, EOL temperature, porosity, gas concentration and oxide layer width.

As a final remark, it should be underlined that the validity of the results here outlined are subject to the code interface analyzed, the present status of the codes and the experimental scenario taken as a reference.