Modeling fission gas behavior in traditional and advanced fuels applied to engineering simulations

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Swelling due to fission gases and fission gas release significantly affect the thermo-mechanical performance of the nuclear fuel rods employed in light water reactors. Fission gas retention in the form of bubbles leads to fuel swelling and the concomitant fission gas release increases the fuel rod inner pressure. Moreover, gas release and precipitation in bubbles affect the thermal conductance of the fuel-cladding gap and the fuel thermal conductivity, respectively.

It follows that modeling of fission gas behavior is an important part of engineering fuel rod analysis, and accurate fission gas models are needed in fuel performance codes. The model of fission gas swelling and release used in Idaho National Laboratory's fuel performance code Bison is a physically-based engineering model that was developed in recent years. The model was originally developed and validated for the analysis of fission gas behavior in uranium dioxide (UO_2). More recently, the concept has been extended to advanced fuels such as uranium silicide (U_3Si_2) and UO_2 doped with chromia (Cr_2O_3). To make up for the existing gap in the experimental data, application to these advanced fuel concepts has leveraged a multiscale approach whereby parameters extracted through lower length scale calculations are used to inform the engineering model.

In this contribution, we provide an overview of the model and present examples of application to the analysis of traditional and advanced fuels with the Bison code. The presentation includes comparisons of results to experimental data for various features of fission gas behavior and fuel rod performance, such as the evolution of fission gas atom concentrations and bubbles, gaseous swelling, and fission gas release.