Abstract

The primary objectives of fourth-generation nuclear reactor concepts revolve around achieving significant fuel burnup, elevated coolant temperatures, and enhanced safety levels, particularly through the utilization of passive safety systems. Among the design concepts that meet these requirements is the high-temperature gas-cooled reactor (HTGR), which incorporates tristructural isotropic (TRISO) fuel particles for power generation.

While the development and qualification programs for TRISO fuel have yielded promising outcomes regarding its potential usage, there is still a need for research and optimization regarding the modelling of fuel performance. The most significant limitations of the current modelling are (1) incomplete representative coating property data as a function of irradiation conditions, (2) insufficient understanding of the interactions between occurring phenomena as irradiation proceeds, (3) uncertainty quantification of different models/methods used in TRISO fuel performance analysis.

In this thesis, a comprehensive literature review is performed regarding the fuel performance limitations and challenges, then a comparison of different methods used in fuel performance tools is performed both for UCO and UO_2 type fuel kernels. The impact of low concentration fission gases on fuel performance analysis is estimated, and finally, uncertainty quantification of geometrical and material data property is conducted and the optimization potential of TRISO fuel particles is discussed. In the scope of current thesis, the Serpent and BISON codes were used.