DESIGN AND PERFORMANCE STUDIES FOR MINOR ACTINIDE TARGET FUELS

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Abstract

Studies have demonstrated the general feasibility of sodium cooled fast reactor core designs for the effective management of minor actinide stockpiles. One of the ways in which this can be achieved is by the heterogeneous recycling of minor actinides in minor actinide fuelled target sub-assemblies. Scenarios include the loading of the target sub-assemblies in in-core locations or alternatively in ex-core locations in the first reflector ring. Preliminary evaluations of the performance of the target sub-assemblies have been made using design methods, however, comparisons with reference methods are needed especially due to the effects introduced by the significant change in the target sub-assembly minor actinide content and composition during irradiation.

More recent studies have been concerned with the development of a prototype gas cooled fast reactor design concept which avoids the sodium handling problems and in particular the safety consequences of the positive sodium void coefficient of sodium cooled designs. Again both in-core and ex-core target sub-assemblies can be considered for the incineration of minor actinide fuels. An extension to this concept is the inclusion of moderating material in the target sub-assembly design. This has the aim of extending the target residence time within the core leading to improved target sub-assembly management where the need for reprocessing of the targets is reduced or even eliminated.

This paper presents the results of two studies. The first illustrates the change in minor actinide target sub-assembly performance due to the consideration of reference rather than more approximate design methods. In particular, the consequences on performance due to changes in resonance self-shielding during irradiation are considered. The issues of helium and fission gas production in the target pins as well as the possible consequences on fuel pin behaviour are also addressed. The second study considers the optimisation of a moderated target sub-assembly design for the gas cooled fast reactor. The use of moderating material allows an increased residence time for the target in the core while retaining a 200 dpa (displacements per atom) deign limit on the fuel clad exposure. However, it also introduces a number of potential difficulties. The presence of the moderator can cause power peaking in immediately neighbouring standard fuel core sub-assemblies. In addition, without adequate design consideration, margins to possible fuel melting can be significantly reduced.

The neutronics design and performance studies presented in this paper have been performed using the ERANOS code and data system developed as part of the European collaboration on fast reactors. The nuclear data used for all of the calculations undertaken during these studies, in particular concerning the minor actinide isotopes, originates from the ERALIB1 adjusted nuclear data library. Evaluations of thermal hydraulic performance have also been carried out during the course of this work. These studies have been performed within the context of the European CAPRA/CADRA project and are sponsored by BNFL.