FUEL CYCLE STUDIES ON MINOR ACTINIDE BURNING IN GAS COOLED FAST REACTORS

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Abstract

The gas cooled fast reactor (GFR) is a Generation IV reactor type considered as an alternative fast neutron reactor design aimed to improve the sustainability of nuclear energy by improving the uranium utilization efficiency. Besides fuel breeding the especially fast neutron spectrum of the GFR also provides excellent opportunities for minor actinide (MA) burning. Development of the design of a 2400 MW_{th} full-scale and a 70 MW_{th} demonstrator GFR (ALLEGRO) is going on in the Euratom sponsored GoFastR project.

The paper presents fuel cycle studies performed at the Budapest University of Technology and Economics (BME) for the assessment of the transmutational capabilities of the 2400 MW_{th} GFR design in the framework of the GoFastR project. Such studies pose two main challenges:

- The evaluation of the different transmutation options can be performed based on the detailed composition of the final waste, which requires the tracking of a wide range of isotopes in the fuel cycle and the determination of the accurate composition of the spent fuel.
- Minor actinide recycling options in transmutation fuel cycles also results in a wide range of possible isotopic compositions of the core, influencing the neutron spectrum and therefore the burnup process.

Most scenario codes contain only cross-section sets at a few burnup steps, which are not flexible enough for such analysis. On the other hand detailed burnup calculations are too time consuming to be inserted in the simulation of the complete fuel cycle. In order to circumvent this problem a new approach were developed for the modelling of the reactor burnup. Multidimensional regression method was used to determine one-group cross-sections as functions of the core composition based on the results of numerous (few thousand) core transport calculations with different isotopic compositions. The set of isotopic compositions for which the core calculations were performed had to cover the space of the possible core compositions with the considered recycling options. With the help of the generated composition dependent cross-section functions, a fast and flexible burnup calculation scheme were developed which can be easily integrated into fuel cycle simulations. The developed model was verified against detailed burnup calculations with satisfactory results.

The burnup model was applied for the analysis of fuel cycle scenarios including a mixed fleet of GFRs and conventional LWRs. Homogeneous recycling of minor actinides into the GFRs was considered and their MA consumption was investigated. The results confirm the expectation that GRFs can also be applied for burning of MAs produced in other reactors. Calculations were performed with different MA ratios in the GFR core and different ration GFRs in the reactor fleet in order to find an optimum.

The present work focuses on the analysis of GFRs, but the developed methodology for burnup modelling can be applied for other reactor types, as well.