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Neutronic Analysis for Using Acid Boric as a Stabilizer of Reactivity Feedbacks in an Aqueous Homogeneous Subcritical System

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Abstract

Irradiating uranium solid targets in research heterogeneous reactors is the conventional approach used to satisfy almost entirely the global demand of Molybdenum-99, the parent nucleus of the most used radioisotope in nuclear medicine, Technetium-99m. Recently, some manufacturers and researchers have manifested their interest in Aqueous Homogeneous Reactors (AHR) and subcritical systems (AHSS) for medical isotope production because of their many advantages, such as lower capital cost and potentially lower operating costs, higher safety standards, easier processing and handling of irradiated fuel, less generation of nuclear waste, and more efficient neutron utilization. However, the large negative values of temperature and void reactivity coefficients, a typical characteristic of the aqueous homogeneous systems provokes reactivity instabilities in AHR and reduces the output of subcritical systems with the solution temperature increase. The use of thermal neutron absorber substances added to the aqueous solution can help to decrease the magnitude of reactivity coefficients since the fissile nuclei importance decreases. In this work, an AHSS conceptual design is studied using a uranyl sulfate solution and boric acid with the main aim of evaluating the potential effects of boron in reducing the magnitude of the temperature and void reactivity coefficients. For this, a computational model of the AHSS conceptual design was elaborated using the Monte Carlo code Serpent 2. Several types of calculations were performed: criticality calculations to determine the convenient boron concentration, fixed-source calculations to evaluate the impact of using boric acid in the system output, and burnup/depletion calculations to monitor the boron concentration and the system reactivity over time.

Keywords: subcritical system; uranyl sulfate solution; boric acid; reactivity coefficient; Serpent 2